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A Summary of Current Program and
Preliminary Report of Progress

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SUGAR RESEARCH

CURRENT GENERAL RECORDS

of the

United States Department of Agriculture
and related work of the
State Agricultural Experiment Stations

This progress report is primarily a research tool for use of scientists and administrators in program coordination, development, and evaluation; and for use of advisory committees in program review and development of recommendations for future research programs. The summaries of research progress include some tentative results that have not been tested sufficiently to justify general release. Such findings, when adequately confirmed, will be released promptly through established channels. Because of this, the report is not intended for publication and should not be referred to in literature citations. Copies are distributed only to members of Department staff, advisory committee members, and others having a special interest in the development of public agricultural research programs.

This report also includes a list of publications reporting results of U.S.D.A. and cooperative research issued during the past year. Current agricultural research findings are also published in the monthly U.S.D.A. publications, Agricultural Research, and The Farm Index.

UNITED STATES DEPARTMENT OF AGRICULTURE
Washington, D. C. 20250

January 1, 1965

ADVISORY COMMITTEES

The research program of the Department of Agriculture is reviewed annually by the following advisory committees:

1. Farm Resources and Facilities Research
2. Utilization Research and Development
3. Human Nutrition and Consumer Use Research
4. Marketing Research
5. Agricultural Economics Research
6. Forestry Research
7. Animal and Animal Products Research
8. Cotton Research
9. Grain and Forage Crops Research
10. Horticultural Crops Research
11. Oilseed, Peanut and Sugar Crops Research
12. Plant Science and Entomology
13. Tobacco Research

ORGANIZATIONAL UNIT PROGRESS REPORTS

The source materials used by the advisory committees are of two types. First, there are Organizational Unit Reports that cover the work of the Divisions or Services listed below. The number prefixes refer to advisory committees listed above that review all of the work of the respective Divisions or Services.

Agricultural Research Service (ARS)

- 1 - Agricultural Engineering
- 1 - Soil and Water Conservation
- 2 - Utilization--Eastern
- 2 - Utilization--Northern
- 2 - Utilization--Southern
- 2 - Utilization--Western
- 3 - Human Nutrition
- 3 - Clothing and Housing
- 3 - Consumer and Food Economics
- 4 - Market Quality
- 4 - Transportation and Facilities
- 7 - Animal Husbandry
- 7 - Animal Disease and Parasite
- 12 - Crops
- 12 - Entomology

Economic Research Service (ERS)

- 4,5 - Marketing Economics
- 5 - Farm Production Economics
- 5 - Resource Development Economics
- 5 - Economic and Statistical Analysis
- 5 - Foreign Development and Trade Analysis
- 5 - Foreign Analysis Division

Other Services

- 4,5 - Farmer Cooperative Service (FCS)
- 4,5 - Statistical Reporting Service (SRS)
- 6 - Forest Service (FS)

SUBJECT MATTER PROGRESS REPORTS

The second type of report brings together the U.S.D.A. program and progress for the following commodities and subjects:

- | | |
|--|--------------------------------------|
| 3 - Rural Dwellings | 8 - Cotton and Cottonseed |
| 6 - Forestry (Other than Forest Service) | 9 - Grain and Forage Crops |
| 7 - Beef Cattle | 10 - Citrus and Subtropical Fruit |
| 7 - Dairy | 10 - Deciduous Fruit and Tree Nut |
| 7 - Poultry | 10 - Potato |
| 7 - Sheep and Wool | 10 - Vegetable |
| 7 - Swine | 10 - Florist, Nursery and Shade Tree |
| 7 - Cross Species and Miscellaneous | 11 - Oilseeds and Peanut |
| Animal Research | 11 - Sugar |
| | 13 - Tobacco |

A copy of any of the reports may be requested from James F. Lankford, Executive Secretary, Oilseed, Peanut and Sugar Crops Research Advisory Committee, Research Program Development and Evaluation Staff, U. S. Department of Agriculture, Washington, D. C. 20250

INTRODUCTION

This report, which is prepared annually, deals with work directly related to the production, processing, distribution, and consumption of sugarcane, sugarbeets, and sweet sorghum. It does not include extensive cross-commodity work, much of which is basic in character, which contributes to the solution of not only sugar problems, but also to the problems of other commodities. Progress on cross-commodity work is found in the organizational unit reports of the several divisions.

The report covers Farm Research; Nutrition, Consumer, and Industrial Use Research; and Marketing and Economic Research. As shown in the table of contents, there is a breakdown of the research program by problem areas.

For each area, there is a statement of (1) the Problem, (2) USDA and Cooperative Program, (3) Program of State Experiment Stations, (4) A Summary of Progress during the past year on USDA and Cooperative Programs, and (5) a list of Publications resulting from USDA and Cooperative Programs.

Research on sugar crops is supported by (1) Federal funds appropriated to the research agencies of the U. S. Department of Agriculture, (2) Federal and State funds appropriated to the ten State Agricultural Experiment Stations, and (3) private funds allotted, largely by sugar industries, to research carried on in private laboratories or to support of State Station or U.S.D.A. work.

Research by USDA

Farm Research in the Agricultural Research Service comprises investigation on introduction, breeding, and genetics, variety evaluation, culture, diseases, nematodes, weed control, insects, and crop harvesting and handling operations and equipment. It is carried out in the following divisions: Crops, Entomology, and Agricultural Engineering. The work involves 61 professional man-years of scientific effort.

Nutrition, Consumer and Industrial Use Research in the Agricultural Research Service pertains to the chemical and physical properties, new and improved products, and new and improved processing technology for both sugarcane and sugar beets. It is carried out in the following research divisions: Northern, Southern, and Western Utilization Divisions; and Consumer and Food Economics, and Human Nutrition Divisions. The work in these divisions involves 22 professional man-years of scientific effort.

Marketing and Economic Research is done in three services. Sugar research dealing with the physical and biological aspects of assembly, packaging, transporting, storing, and distribution from the time the product leaves the farm until it reaches the ultimate consumer is conducted by the

Agricultural Research Service. There is no current work in this area. Economic research conducted in the Economic Research Service deals with marketing costs, margins and efficiency; market potential, supply and demand, and outlook and situation. Research in cooperative marketing is conducted by the Farmer Cooperative Service. The work reported herein is done by the following divisions: Marketing Economics, Economic and Statistical Analysis, and Marketing. The sugar research in these services involves 2.8 professional man-years of scientific effort.

Interrelationships Among Department, State and Private Research

A large part of the Department's research is cooperative with State Experiment Stations. Many Department employees are located at State Stations and use laboratory and office space close to or furnished by the station. Cooperative work is jointly planned, frequently with the representatives of the producers or industry participating. The nature of cooperation varies with each study. It is developed so as to fully utilize the personnel and other resources of the cooperators, which frequently includes resources contributed by the interested producers or industry.

Research by industry and other organizations is sponsored primarily by beet and sugarcane companies, processors, sugar refiners, and chemical companies.

Beet sugar companies conduct applied research on breeding and genetics, nutrition, and agronomic practices, including production and processing of sugar beet seed. The Department supplies new varieties and conducts the basic research needed by the beet sugar companies in their research program.

Large companies that grow sugarcane in Florida, Louisiana, Puerto Rico, and Hawaii conduct research on breeding, variety evaluation, cultural practices, fertilization, and the use of chemicals to expedite (1) the accumulation of sugar in sugarcane and (2) harvesting operations. Valuable developments from such research is made available to Federal and State scientists who cooperate by conducting the basic research necessary to such activity.

Chemical companies conduct research for the development of more effective fungicides for the control of diseases which attack sugar crops and for seed dressings. Also some chemical companies are engaged in the formulation of chemicals for use as desiccants, as fungicides, as growth stimulants, and as retardants to hasten maturity of sugarcane. Federal and State groups provide the basic and fundamental phases essential to this area of research.

Basic research done by the Department and States will be utilized by industry and other organizations in their research programs, especially in the further development of improved products and equipment. Industry's cooperation in supporting sugar research at Federal and State Stations has contributed greatly to its success.

I. FARM RESEARCH

SUGAR PLANT CULTURE BREEDING, DISEASES, AND VARIETY EVALUATION Crops Research Division, ARS

Problem. Sugar production in the United States is below national consumption. For more than a quarter century our sugar requirements have been provided through quotas of domestic production and foreign importations established by Acts of Congress. Sugar crops, which are nonsurplus, have major problems pertaining to quality and efficiency of production. These problems have acquired broader meaning with the implementation of the Sugar Act Amendment of 1962 which provides for growth and expansion of the domestic sugar industry.

Major diseases of sugar crops, especially virus yellows of sugarbeets and ratoon stunting of sugarcane, unfavorably affect quality and continue to take a heavy toll of production. New strains of the curly top virus of sugarbeets and of the mosaic virus of sugarcane have been discovered. They are capable of severely damaging varieties that are resistant to strains of these viruses formerly prevalent in a region. The major diseases, as well as new strains of the pathogens, are serious hazards to stable production of sugar crops in all regions of the country.

Soil-inhabiting pathogens attack the root systems of sugarbeets and of sugarcane, inflicting heavy losses; and the microbial flora of the rhizosphere may have a bearing on the failure of sugarcane plantings to endure repeated harvest and regrowth and on the decline in variety productivity. Basic information on the etiology and epidemiology of diseases of sugar crops is urgently needed for the development of methods of control through the application of direct measures, biological antagonism, and breeding for resistance.

Germ plasm is available which could provide factors for resistance to most of the major sugarbeet pathogens, including the cyst nematode. Breeding should be accelerated to utilize this wealth of germ plasm in the development of resistant lines, varieties, and hybrids. The bank of germ plasm of sugarcane and sweet sorghum has been greatly enriched through importation of breeding material, and the World Collections of these crop plants should be further utilized in the development of productive varieties that are of high quality, resistant to diseases and insects, and tolerant to low temperature.

The application of improved field practices of culture and nutrition to sugar crops has resulted in a marked increase in acreable yield of beets and cane, but sucrose percentage has shown a downward trend. Expanded research is needed to establish fundamental principles in physiology and genetics, whereby concomitant improvement can be brought about in both quality and yield under high levels of fertility. Basic research is needed to give a better understanding of genetic, cytoplasmic, and

environmental factors conditioning male sterility in sugar crops and to provide information on techniques for the use of this character as a tool in hybrid seed production. The labor requirements for sugar production should be reduced through the development of varieties of sugar crops that are suitable for mechanized farming.

PROGRAM--USDA AND COOPERATIVE PROGRAMS

Type of research. The Crops Research Division has a continuing, long-term program of basic and applied research on sugarbeets, sugarcane, and sweet sorghum with 47 professional man-years devoted as follows: 22.2 to breeding and genetics, 9.7 to diseases, 8.7 to quality and variety evaluation, and 6.4 to culture and physiology. These man-years are distributed for crops as follows: Sugarbeets - 13.4 to breeding and genetics; 4.8 to diseases; 3.7 to quality and variety evaluation; and 2.7 to culture and physiology; Sugarcane and Sweet Sorghum - 8.8 to breeding and genetics; 4.9 to diseases; 5.1 to quality and variety evaluation; and 3.7 to culture and physiology.

Locations and cooperation. In addition to research at Beltsville, Maryland, and at Federal Field Stations in California, Utah, Colorado, Louisiana, Florida, Mississippi, and Georgia, investigations are conducted cooperatively under Memoranda of Understanding or Cooperative Agreements with State Experiment Stations on sugarbeets in California, Utah, Colorado, Michigan, Minnesota, and New York; and on sugarcane and sweet sorghum in Louisiana, Florida, Mississippi, Alabama, Georgia, Tennessee, South Carolina, Texas, Kentucky, and Puerto Rico.

Other organizations. Cooperative sugarbeet work on contributed funds is conducted at Salinas, California; Logan, Utah; Fort Collins, Colorado; and Beltsville, Maryland, with the Beet Sugar Development Foundation; and at East Lansing, Michigan, and Beltsville, Maryland, with the Farmers and Manufacturers Beet Sugar Association; and at Salinas, California, with the Union Sugar Division, Consolidated Foods Corporation, and the California Beet Growers Association. Research on sugarcane and sweet sorghum is carried out in cooperation with the American Sugar Cane League in Louisiana and Florida, with the Cairo Cane Growers' League in Georgia, with the Hawaiian Sugar Planters' Association in Hawaii, and in Puerto Rico on funds contributed by the Association of Sugar Producers of Puerto Rico and the Land Authority of Puerto Rico. Sugarbeet breeding material is being tetraploidized in Spain, and research is being conducted on yellow wilt of sugarbeet in Chile under Public Law 480 grants. In October 1963, a Public Law 480 Research Grant FG-IN-170 (A7-CR-1) was approved for research hybridization of U. S. and Indian sugarcane clones with Saccharum spontaneum and other species to develop cold-, disease-, and pest-resistant germ plasm suitable to evolve superior commercial varieties in the United States.

PROGRAM OF STATE EXPERIMENT STATIONS

Scientists at the State Experiment Stations are engaged in basic and applied research on plant breeding, plant pathology, plant physiology, and agronomy. The research is conducted cooperatively with the Department and with industry in the major sugar-producing States. This research is continuing to provide useful fundamental information for the improvement of sugar production.

The relationship between moisture supply to sugarcane and various physiological processes is being studied in Hawaii. The use of sugarcane for forage is being explored in Florida. Dates of harvest and post-ripening chemical treatments are being studied for their effect on sucrose content and purity. Breeding of sugarcane involves testing of varieties for adaptation in several States. A collection of germ plasm is being assembled and maintained in Puerto Rico. Resistance to mosaic and other diseases is being sought in Louisiana. The alcoholic, lactic, and citric fermentation of molasses is being studied in Puerto Rico to increase the efficiency of molasses utilization.

Sweet Sorghum varieties are being evaluated for local adaptation for sirup production in several States.

Research on sugarbeets involves preplanting tillage, cultivation, trace elements, rotations, and the relation of sucrose content of sugarbeets to soil fertility, nitrogen fertility, environmental factors, cultural practices, and nutrient levels indicated by plant tissue tests. Some breeding for resistance to diseases is in progress. Several States are evaluating varieties and cultural practices to determine the feasibility of establishing new sugarbeet areas.

Scientists at colleges and universities in States where sugar crops are grown are conducting research on many of the disease problems of these crops. In the case of sugarcane, three research projects are designed to learn more concerning the role of nematodes in disease problems of this crop. Recent findings in this work have contributed new knowledge on the effect of the clover cyst, ring, stunt, spiral, stubby root, and lesion nematode on sugarcane. Basic studies using tissue culture techniques promise to provide new insight into the biochemical specifics of selected nema deprecations, and thus contribute not only to eventual improvement in disease control in sugarcane, but also to biological science in general. Other scientists are concerned with research on the destructive mycoses of sugarcane, such as those caused by Cytospora, Phytophthora, and a number of other fungi. Portions of this research are also designed to develop new techniques for the isolation of germ plasm resistant to these diseases. Some research projects involve studies on virus diseases of sugarcane such as stunt and mosaic.

New findings on seedcane transmission of the ratoon stunting disease, the interaction of viruses, and on serological identification of viruses are significant contributions.

Research on sugarbeet diseases is making available new information which is essential to the control of diseases such as Aphanomyces root rot, Rhizoctonia blight, Cercospora leaf spot, beet yellows, beet mosaic, and Fusarium root rot. New strains of the beet mosaic virus have been isolated, which will aid in the analytical procedures used for obtaining resistance. Host range of this virus and development of an effective antisera for the yellow dwarf virus are phases of the work being pursued in two research projects. Studies on the use of soil fumigants for the control of nematodes and fungi that attack sugarbeets are in addition contributing new knowledge on microbial interactions and on the role of selected metabolites involved in pathogenesis. Recent findings in studies on Cercospora disease have resulted in the biochemical characterization of two components contributing resistance to this disease and may eventually make possible a full understanding of this mechanism in the beet plant. Related research in progress on the role of bacteria in fungal root rot of beets is providing new research concepts that are most useful in investigations of many diseases. A few studies are directed toward the use of crop residues and specific chemicals for use in the control of diseases of sugarbeets. These are a few of the research areas being investigated with respect to sugar crops.

The total research effort is approximately 27.1 professional man-years; of which 1.5 is for culture, 7.3 for breeding and genetics, 6.7 for diseases, and 11.6 for varietal evaluation.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

A. Breeding and Genetics

a. Sugarbeets

1. New Monogerm Hybrids. Two new monogerm sugarbeet hybrids, which have been designated US H7 and US H8, were released for seed production in 1964 and for grower use in 1965. These 3-way hybrids are based on a male-sterile monogerm F_1 as the seed-bearing parent. The characteristic of the pollinator used in the commercial seed production determines the specific regional adaptation of the commercial hybrid. Cytoplasmic male sterility is the generative device employed to bring about hybridization in the F_1 monogerm parent as well as in the production of commercial 3-way hybrid seed. US H7 and US H8 have shown excellent performance in sugarbeet districts of California.

2. Utilization of Monogerm Seed. Monogerm varieties comprised 88.5 percent of the seed crop in 1962 and 86.8 percent in 1963. For 1964, the estimate is approximately 95 percent. The tailoring of American varieties of sugarbeets, through genetic procedures, for a change-over from multi-germ varieties that require hand labor for singling and thinning to the new monogerm varieties that facilitate mechanization is a noteworthy accomplishment of the U. S. Department of Agriculture and cooperators in the beet sugar industry and seed-producing enterprises. Beginning with a small experimental quantity of commercial monogerm seed in 1955, an essentially complete change-over occurred in a decade. This achievement is viewed with astonishment by sugarbeet investigators in other countries.

3. Male Sterility. The sugarbeet has a natural tendency for cross-pollination; however, the tendency is never fully restrictive and self-fertilization occurs. The production of commercial sugarbeet seed that is completely hybrid was beyond the attainment of the seedsman before the discovery that pollen sterility in the sugarbeet is conditioned by both cytoplasmic and genetic factors and that proper manipulation of these factors in a breeding procedure may produce a male-sterile population that is fully female fertile. Using cytoplasmic male sterility as the device to bring about the hybridizations, the commercial production of hybrid sugarbeet seed requires only the supplying of a complementary pollinator to the male-sterile parental line. The proper combination of cytoplasmic and genetic factors in sugarbeet breeding material is discouragingly low; furthermore, the expression of the character is unstable under some environments. Basic research is being conducted on the factors that have been postulated and on the physiology of the character. The transmission of cytoplasmic male sterility from generation to generation simulates, in some respects, a seedborne virus disease. Research has firmly demonstrated that entities conditioning male sterility in the sugarbeet are not transferred by grafting from stock to scion, while the curly top virus readily moves through the graft union. Male sterility is less stable at high temperatures and is influenced by plant

nutrition. The discovery that complete restoration of pollen fertility in the progeny of a male-sterile sugarbeet can be induced by genetic factors has application in breeding, and this genetic principle can be used to facilitate the commercial production of double cross hybrids.

4. Interspecific Hybrids. Three botanical relatives of the sugarbeet (Beta vulgaris), found in the Canary Islands and on the northwest coast of Africa, constitute a source of valuable germ plasm that previous research efforts failed to make available for sugarbeet improvement. These three wild species (B. patellaris, B. procumbens, and B. webbiana) are the only forms of Beta that are immune to the cyst nematode (Heterodera schachtii) and to leaf spot (Cercospora beticola)--two major diseases of the sugarbeet and of other cultivars of beet. To the sugarbeet scientists these wild forms of beet are not prepossessing, because of their fibrous roots and their viny tops. Although crosses between the sugarbeet and these wild species could be obtained, until recently the unthrifty condition and extreme sterility of the interspecific hybrid prevented utilization of the genes for disease immunity. Cytological investigations have presented explanations for the irregular meiotic configurations that occur in gamete formation in the interspecific hybrid and supplied information that has guided an approach to the genetic transfer of genes from these Beta spp. to the sugarbeet.

Through persistent efforts, the extreme nematode tolerance of Beta patellaris has been transferred to the sugarbeet. Not all subsequent populations derived from the interspecific hybrids are immune to the nematode. Screening of large backcross populations under nematode exposure has permitted the selection of 33 plants that are extremely resistant to the pathogen and also possess morphological characters similar to the sugarbeet. Thus, for the first time, valuable genic components of the viny species of Beta have been extracted through genetic and cytological research and transferred to the sugarbeet.

5. Chemical Genetics. Studies on the comparative effects of levels of nitrogen, potassium, and sodium in the petioles and thin juice on weight per root, percentage sucrose, and apparent purity in sugarbeets have shown that the associations between levels of total nitrogen in thin juice, percentage sucrose, and percentage purity are negative; furthermore, for the latter the association is so close ($r = -0.95$) as to practically preclude the possibility of genetically combining high total nitrogen in the thin juice with high percentage apparent purity. Results of chemical genetics further indicate that higher levels of total nitrogen, potassium, and sodium in the petioles are conducive, if not essential, to the production of high root yields. This research indicates that the metabolic requirements of higher yields of roots, percentage sucrose, and percentage apparent purity can be met by producing and growing genotypes which at the time of harvest have higher levels of total nitrogen, potassium, sodium, and phosphorus in the petioles rather than in the thin juice. This important finding shows that populations can be bred that will have the high levels of nonsugar chemicals in the foliage

rather than in the roots.

b. Sugarcane

Improved varieties having high quality, resistance to diseases, to insects, and to cold damage and that are adapted for mechanical harvesting are developed through breeding research at Canal Point, Florida; Houma, Louisiana; Meridian, Mississippi; and Cairo, Georgia. Approximately 75 percent of the parental varieties are superior selections from progenies of former crosses; some special crosses were made in 1963 to broaden the genetic base and provide material for studying the inheritance of important varietal characteristics. In the 1963-64 crossing season, 401 crosses made at Canal Point provided 737,000 viable seed to produce more than 300,000 seedlings for field evaluation in Louisiana, Florida, and the sirup producing areas. More than 50 percent of the seedlings were discarded because of susceptibility to mosaic.

1. Inheritance Studies. Second backcross progenies having S. spontaneum as one parent were highly susceptible to mosaic. Since sixty-five percent of the seedlings became infected, the S. spontaneum clones involved are not promising sources of genetic factors for resistance. Studies are in progress to locate parental clones resistant to strains of the virus common in commercial fields.

2. Selections. More than 8,000 sugarcane seedlings were selected in Louisiana, Florida, Mississippi, and Georgia during 1963 for further, more critical evaluation. Evaluation of these promising clones under a range of environmental conditions is in cooperation with Agricultural Experiment Stations in Louisiana, Florida, Georgia, Mississippi, and Puerto Rico, and the American Sugar Cane League, the Cairo Cane Growers League, the Association of Sugar Producers of Puerto Rico, and the Land Authority of Puerto Rico.

3. Cytogenetic Studies. Seedlings from the cross S. officinarum x (S. officinarum x S. robustum) had mostly $2n = 80$ -chromosomes or simple aneuploid deviations from that number indicating normal transmission by the female parent and surprisingly regular transmission by the F_1 male parent. Cytological studies were initiated on sugarcane subclones selected to study senescence. Buds from the top, middle, and bottom of stalks of selected varieties were planted in the greenhouse at Beltsville to provide material for this long-time study.

4. Genetic Studies of the Mosaic Virus. Investigations were initiated at Beltsville to isolate pure strains of the mosaic virus for genetic studies. Technique studies are in progress to purify living virus particles as required for identification and dilution of the particles for research on the subject. Progress has been made in identifying major factors that influence purification of the mosaic virus.

c. Sweet Sorghum

Development of varieties of sweet sorghum superior in yielding ability, quality of juice for sugar and sirup production, and resistance to diseases is carried out at Beltsville, Maryland; Meridian, Mississippi; Cairo, Georgia; and Brawley, California. Preliminary studies at Meridian, Mississippi indicate that hybrid vigor is not evident in quality of the juice for sirup and sugar production. Hybrid varieties produced higher yields of stalks that were more susceptible to lodging than the parents. There were no visible desirable mutations in R2 progenies from irradiated seed; more than 50 selections from these progenies will be evaluated further for yield and quality.

B. Diseases

a. Sugarbeets

1. Virus Yellows. Yellowing of sugarbeet is a disease complex in which two or more viruses induce similar symptoms. The damage depends upon the virulence of the strain of the virus and the development of the sugarbeet at the time of infection. Inoculation tests in 1962 showed losses in root yield of 4.4 percent and 24.2 percent due to western yellows and beet yellows, respectively, and 28.9 percent due to infection by both viruses. In 1963, similar field tests with the same monogerm hybrid showed losses in root yield of 19.2 percent and 34.7 percent due to western yellows and beet yellows, respectively, and 40.0 percent attributable to a combination of the two viruses.

The potential losses from virus yellows are being combated through the development of tolerant varieties. The fourth successive selection in US 75 for yellows resistance has reduced the losses in root yield by almost 50 percent. Line 671, which has been subjected to selection for only one generation, showed 30 percent loss in root yield from virus infection, while the unselected parental line showed a loss of 46 percent. The results of selections for yellows resistance in US 75 and Line 671, as well as in many other sorts, clearly demonstrate that control of the disease is feasible through breeding and that progress is being made in the development of resistant breeding material. The gain from selecting for resistance to virus yellows has been expressed primarily as a protection against losses in root yield, but the selections from US 75 tended to maintain sucrose percentage as well.

2. Nematode Disease. The cyst nematode (Heterodera schachtii) is a major pest of the sugarbeet. In a program of breeding for resistance it was found that the nematode was an accessory to the damage induced by other soil-inhabiting pathogens. Rhizoctonia solani appears to be the major pathogenic fungus in the nematode inoculum obtained from California soils. In most sugarbeet districts, this fungus is a major cause of a seedling disease and also of root rot. In experimental tests, the damage to sugarbeet seedlings was greatly enhanced when the cyst nematode was

associated with pathogenic fungi. It is thought that in soil infested with the cyst nematode the depredations of this eelworm predispose the sugarbeet to attack by other soil pathogens, thereby increasing seedling mortality and root decay. Excellent progress has been made in developing breeding material with resistance to the disease complex, but specific resistance to the nematode cannot be attained until the relative damage of the separate causal agents is determined and precise techniques developed for exposure of sugarbeet plants to populations of the cyst nematode that are free from associated pathogens.

Several species of fungi are associated with cyst nematode infection of the sugarbeet. One of these (Phytophthora drechsleri) causes a disease of safflower. In greenhouse tests, the sugarbeet isolates caused a typical Phytophthora disease of safflower; and, conversely, the safflower isolates of the fungus were pathogenic on the sugarbeet. Thus, the discovery that Phytophthora drechsleri causes a disease of sugarbeet and safflower has an important bearing on cropping sequence on farms where both crops are grown.

3. New Strains of Pathogens. The insidious development and dissemination of new strains of pathogens require scientific surveillance if protective measures are to keep abreast with these hazards of sugarbeet production. Beet yellow stunt virus, which causes a disease of lettuce and sugarbeet has been found in California. The symptoms of the disease place it in the yellowing complex of sugarbeet, but the importance of the virus is yet to be determined. Recently, two vein yellowing strains of the curly top virus have been isolated from sugarbeet from Arizona. Both strains are transmissible to sugarbeet by the beet leafhopper, Circulifer tenellus. The first symptom on sugarbeet is typical of curly top, including the curling of the leaves. The infected plants tend to recover from leaf deformities with the development of conspicuous yellowing of the leaf veins. The relative importance of these new mutations of the curly top virus is being determined. Strains of the curly top virus that differ in virulence on varieties of sugarbeet have been known for several years. Strain 11, which was found in Idaho, was the first that could induce severe damage on varieties of sugarbeet that had previously shown resistance to curly top. Isolates equal to Strain 11 in virulence have been found in California and Utah, and all have been obtained from sugarbeet. Beet leafhoppers collected in their natural habitat in the desert region of northern Utah were found to carry the curly top virus. As a group, the virus isolates from the leafhoppers collected in the desert were as virulent as those from sugarbeet growing in the irrigated area of the State. Four of the eight virus isolates from the beet leafhoppers collected in the desert were as severe as Strain 11. This finding indicates that strains of the curly top virus that are different in virulence on the sugarbeet occur in the desert breeding areas of the vector. These virulent strains may be brought into the sugarbeet districts each year by migrant leafhoppers.

b. Sugarcane

Most of the research on diseases of sugarcane relates to the major virus diseases, mosaic and ratoon stunting. Both diseases reduce yields of cane and of sugar in Louisiana and Florida and they are apparently related to the decline in yield of sugarcane varieties.

1. Mosaic. Studies are in progress in Louisiana and Florida to identify varieties of the World Collection that are resistant to strains of the disease. Resistant parental varieties are urgently needed for the breeding program. Studies at Meridian, Mississippi indicate that light intensity influences the infection of sugarcane mosaic, by manual inoculation. The rate of leaf drying after inoculation also influences infection; the response to these conditions is influenced by temperature. In Louisiana, studies with one of the vectors of the mosaic virus, the brick-red sowthistle aphid, indicate that the insects become viruliferous within 5 minutes after feeding on an infected plant and that they can transfer the virus within 5 minutes after feeding on healthy plants. The insect loses its ability to transmit the mosaic virus after 1½ hours on healthy plants.

2. Ratoon Stunting Disease. Data from 18 experiments at Houma during the past decade indicate an increase in yield of cane and sugar per acre from heat treatment of seedcane of C.P. 44-101. Yields of C.P. 52-48 were not influenced by heat treatment. Limited data indicate that yields of the new variety C.P. 55-30 are not influenced by the ratoon stunting disease as much as those of C.P. 44-101.

c. Sweet Sorghum

1. Smut (Sphacelotheca cruenta). A very effective method of isolating the smut fungus was developed at Meridian. The method involves opening johnsongrass flowers in April prior to emergence and planting floret fragments, without treatment. The florets, heavily infected with the smut fungus, are in an aseptic condition.

2. Zonate Leaf Spot (Gloeocercaspora sorghi). Studies are in progress to determine the relative susceptibility of mature and immature tissues of sweet sorghum to the zonate leaf spot fungus. Comparisons under photo-periodic control conditions indicate excellent infection on young leaves by artificial inoculation; it is not known at this time whether the infection can be obtained on older leaves. The evaluation of lines in the World Collection of Sweet Sorghum varieties for resistance to zonate leaf spot is in progress.

C. Quality and Varietal Evaluation

a. Sugarbeets

1. Improvement in Quality. Field trials conducted in the Great Lakes region in cooperation with Farmers & Manufacturers Beet Sugar Association indicate progressive improvement in monogerm hybrids. Some of the improvement can be attributed to selection of better monogerm male-sterile lines as seed-bearing parents and to selection of pollinators of excellent quality. SP 5822-0 was used as a pollinator and is excellent in technical quality, as indicated by thin juice purity. According to this quality determination, SP 5822-0 would give higher sugar recovery than other varieties in the test which had produced the same quantity of gross sugar per ton of roots. The excellent quality characteristic of SP 5822-0 is imparted to its hybrid progeny.

2. Regional Variety Tests. Disease has a depreciative influence on sugarbeet quality in most districts of this country; therefore, disease tolerance is an important criterion in variety evaluation. Approximately 850 entries of breeder seed, which were mostly monogerm, were evaluated in Utah for curly top resistance. A larger number were screened in Colorado and Michigan for leaf spot resistance and at Beltsville, Maryland, for both leaf spot and black root resistance. These field tests revealed a wealth of basic monogerm breeding material of excellent quality and with disease resistance. The utilization of this breeding material will require further evaluations, including tests for the vigor of hybridity.

A variety such as SP 6051-0, carrying resistance to both leaf spot and curly top, is required in the High Plains region where both diseases may occur in epidemic proportions. In 1963 field tests in which both diseases occurred, this variety gave a root yield approximately double that of varieties that were resistant only to leaf spot. In California, the quality of the sugarbeet, as well as the yield, is greatly influenced by bolting. Triploid hybrids have shown significantly higher resistance to bolting than their corresponding diploids. The triploid hybrids were excellent in root yield, but they were inferior in sucrose percentage and susceptible to curly top. Tetraploid lines of sugarbeet are of primary interest as parental material for the production of triploid hybrids. It is of interest that tetraploidization of some lines enhance disease resistance; and in one inbred line the tetraploid phase was completely avoided by the spider mite, whereas the diploid counterpart was severely damaged by the pest.

b. Sugarcane

New varieties developed in the breeding program at Florida and Louisiana are evaluated for yield, quality, and disease and cold resistance in cooperation with Agricultural Experiment Stations in Louisiana, Florida, Mississippi, Alabama, the American Sugar Cane League, and the Cairo Cane Growers League. In 1963, varietal evaluations on more than a dozen different soil types and growth conditions indicated superiority of three

new selections in Louisiana and two in Florida.

1. Cold Resistant Varieties. Selected parental clones and commercial varieties that show some cold resistance were planted at Meridian, Mississippi, where freezing temperatures occur annually. The varieties will be evaluated for resistance of mill cane to cold damage and for the effect of low temperatures on succeeding stubble crops. Varieties that have some resistance will be evaluated further, under laboratory and field conditions in Louisiana and Florida.

2. New Varieties. In Louisiana, the new variety released to growers in 1963, C.P. 55-30, produced higher yields of sugar per acre than the standard commercial variety C.P. 52-68. Three unreleased varieties, C.P. 58-48, C.P. 59-43, and L. 60-1, were comparable to C.P. 55-30 in yields of sugar per acre. In Florida, C.P. 56-59 and C.P. 57-614 were superior to the commercial variety C.P. 50-28 in yield of sugar per acre.

c. Sweet Sorghum

New varieties of sweet sorghum developed in breeding programs at Beltsville, Maryland and Meridian, Mississippi are evaluated in cooperation with Agricultural Experiment Stations in Louisiana, Alabama, Georgia, South Carolina, Kentucky, Mississippi, and Tennessee for sirup production, and in Louisiana and California for sugar production. Limited experiments are conducted in Texas in cooperation with the Agricultural Experiment Station, and at Beltsville, Maryland. Varieties are evaluated on more than 20 soil types and under a wide range of growth conditions.

1. New Varieties. A disease resistant variety, Mer. 55-1, promising for sugar production in Texas, Louisiana, and other areas will be released for commercial culture in 1964; release of the variety has been delayed to produce an adequate supply of seed. Mer. 61-8 is another unreleased variety promising for sugar production. Two new varieties, Mer. 59-1 and Mer. 60-2 are promising for sirup production.

D. Culture and Physiology

a. Sugarbeets

1. Foliage Efficiency. Physiological research has demonstrated that the position of sugarbeet leaves in relation to light source profoundly influences their efficiency as well as the net accumulation of metabolic products. When the leaves of a sugarbeet are clumped into an upright position, the process of photosynthesis, as measured by CO₂ utilization, may be reduced by 2½ times from that of leaves in spread array for maximum light reception. The efficiency of the foliage is greatly reduced if the energy of the plant is directed to the production of excess foliage through improper nutrition and irrigation that induces severe crowding and shading of leaves. Plant populations per acre, spacing, and nutrition greatly influence size of sugarbeet foliage and array of

leaves. Physiological research has indicated that luxuriant foliage may be inefficient per unit area.

2. Seed Physiology. Tightness of the cap over seed cavity has been shown to adversely affect rate of germination of monogerm seed. Some progress has been made on the development of techniques for the removal of the cap; but, more importantly, research has demonstrated that harvest of seed at full maturity will greatly improve quality. Sugarbeet seed under refrigeration has remained viable for 35 years. When the seed was placed in storage in 1928, it germinated at 83.5 percent, but in 1963 the germination had reduced to 22.1 percent. The surviving seed, however, produced normal plants.

3. Fertilization. Cooperative field study in 1963 demonstrated that when the rate of nitrogen fertilization of sugarbeet was increased, the sucrose percentage declined and that clear juice purity declined to an even greater extent. Clear juice purity was also decreased by increasing the space between the plants within the row.

b. Sugarcane

1. Growth of Varieties. Significant differences in the growth of varieties were observed in 1963 at Houma, Louisiana. C.P. 55-30 grew faster early in the season than all other varieties; the rate of growth late in the season was less than that of C.P. 52-68. N. Co. 310 had the slowest rate of growth of any variety during the entire season.

2. Inversion of Sucrose. Studies at Houma during 1963 indicate that inversion of sucrose was greatest when the leaves were removed by burning, based on analyses of 5 varieties stored at 75° F. for one week.

3. Photosynthesis in Sugarcane. Data from experiments in Louisiana with $C^{14}O_2$ indicate that varieties differ as much as 40 percent in the rate of photosynthesis. Young unfolded leaves have the highest rate of photosynthesis; the rate decreases with age of the leaves. Lower surfaces of leaves admit up to four times the amount of $C^{14}O_2$ as upper surfaces.

4. Cold Resistance. Sugarcane subjected to a temperature of 22° F. in Louisiana deteriorated rapidly in storage. Deterioration of standing cane was also important when harvesting was delayed 10 days or more following the freeze; there was a decrease in Brix, sucrose, and purity and an increase in acidity.

5. Technique for Evaluating Varietal Resistance to Cold Damage. Sugarcane stalks are frozen at 24° F. for 13 hours. The amount of frozen stalk tissue is weighed and recorded in percent of fresh weight to provide a fairly reliable estimate of the resistance to cold damage. Data obtained at Houma in 1963 show a range of the amount of frozen tissue from 2 percent in C.P. 62-291 to 100 percent in L. 62-24.

The total acidity of some sugarcane varieties may be excessive before a freeze occurs; it varies widely between varieties. There are differences in total acidity in cane from different areas; it may increase with maturity, when damaged by burning or diseases, or when kept in storage, and it may decrease with extensive lodging or lower topping.

6. Flowering of Sugarcane. In Hawaii, flowering was prevented by exposing sugarcane plants to temperatures of 60-65 degrees F. for 11 hours during floral initiation. When these temperatures occurred after floral initiation, flowering was delayed in some varieties and prevented in others. Removal of roots of sugarcane growing in solution cultures after August 8, prevented flowering, indicating that roots may have some role in the process. The addition of p hydrazinobenzenosulfonic acid to the standard solution for preserving sugarcane tassels during pollination in Hawaii increased usefulness of the solution and reduced total cost for the work.

c. Sweet Sorghum

1. Lime applications adequate to change the pH of the top soil from 5.2 to 6.6 had no influence on yield, and quality of sirup in Mississippi. Propazine applied as a preemergence spray prevented weed growth in sweet sorghum for 4 to 6 weeks after germination; the chemical can be used effectively for controlling weeds in commercial plantings of the crop.

2. Sweet Sorghum plants in drills, single plants 4 inches apart, at Brawley, California grew faster early in the season than those in hills of 4 plants every 24 inches. Close-spaced plants flowered earlier; there was no significant difference in yield.

3. Techniques designed to improve the production of sirup from sweet sorghum following storage of the stalks are in progress at Meridian. Treatment of the stalks in hot water prior to milling influenced quality of the juice and sirup. Studies are in progress to determine the components of the juice that were influenced by the heat treatment.

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WEED AND NEMATODE CONTROL
Crops Research Division, ARS

Problem. Weeds cause losses in crops, orchards, grazing lands, forests, water supplies, and irrigation and drainage systems. The losses caused by weeds can be reduced by finding more effective, chemical, biological, mechanical, cultural and combination methods of weed control. Improved weed control methods will facilitate farm mechanization, greatly increase production efficiency, and improve the efficiency of the use of human and land resources in agriculture.

Plant-parasitic nematodes occur in all soils used for growing of crop plants and attack all kinds of plants grown for food, forage, fiber, feed, or ornamental purposes. It has long been known that severity of attack of certain fungi is greatly increased if nematodes are present; and nematodes have been known to be the vectors of several plant viruses. There is a need for improvements in the methods of controlling nematodes by crop rotations, cultural practices, chemicals, and biological methods on sugar crops.

USDA AND COOPERATIVE PROGRAM

Much of the weed control research in the Department is cooperative with State Experiment Stations, other Federal agencies, industry and certain private groups. The work is cross commodity in nature. The weed control program involves a total of 58 professional man-years. Of this total, 2.3 is specifically directed to weed control in sugar crops. The program is being conducted in Prosser, Washington; St. Paul, Minnesota; and Houma, Louisiana.

The Federal scientific effort devoted to basic and applied nematode research is 19.0 professional man-years, of which 2.6 is devoted to applied research in sugar crops at Salinas, California; Baton Rouge, Louisiana; and Logan, Utah.

PROGRAM OF STATE EXPERIMENT STATIONS

State experiment stations are conducting basic and applied research in weed control. These studies involve evaluation of selective herbicidal properties of new chemicals to show the relation between chemical structure, herbicidal activity and weed-crop selectivity; the nature, behavior, and effect of herbicides on their degradation products in and on plants and plant products; the mechanism of herbicidal action; influence of climate, plant morphology and soil characteristics on the effectiveness of herbicides in selectively controlling weeds and on their persistence in plant tissue. Studies are being conducted on the movement and persistence of

herbicides in various soil types and the phenomena involved in absorption and other interaction of herbicides with clay complexes.

Weed life cycles and growth habits are being studied under different environments to determine the most susceptible stage of vulnerability to herbicides and other control measures. Other aspects that are currently being investigated are: competition between weeds and desired plant successions following control measures including replacement vegetation and management practices. Relation between weeds and biological control organism that attack them in different environment is being studied on a limited scale.

Nematode investigations are being conducted at most of the State stations and many of these scientists participate in Regional Research Projects concerned with phytonematology. Through these and other projects at the various institutions scientists are contributing new knowledge on the genetics, physiology, and pathology of nemas. Some station scientists, as a result of their recent findings on nemas as vectors of viruses, are conducting intensive investigations of the biologies of this process.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

A. Weed Control

a. Sugarbeets. In Washington, competition studies showed that thrifty sugarbeets which were maintained weed-free for 10 to 12 weeks remained weed-free until harvest. Annual weeds did affect sugarbeet yields when left uncontrolled for less than 12 weeks, but proportionally decreased yields during longer periods of competition. Uncontrolled lambsquarters and barnyardgrass reduced yields by 93% and 50%, respectively. Preplant, soil-incorporated treatments with PEBC provided excellent to satisfactory control of barnyardgrass, pigweed, and lambsquarters without affecting yield or sugar content.

In Minnesota, very early postemergence applications of experimental herbicides, pyrazon and a substituted uracil, gave excellent control of the dominant weed, wild mustard. Several thousand acres of sugarbeets were treated with endothall by growers, based on previously developed methods for postemergence control of wild buckwheat. In controlled environment studies the dipotassium salt of endothall was superior to the disodium salt at low temperature.

b. Sugarcane. Five herbicides evaluated for pre-emergence control of Johnsongrass seedlings in sugarcane in Louisiana were equivalent to the recommended fenac treatment. Three of these herbicides, bromacil, 6-6-butyl-2-chloro-o-acetololuidide, and 2,3,6-trichlorophenylacetone, also effectively controlled winter-growing broadleaved weeds. Dicamba, picloram, and silvex were superior to several formulations of 2,4-D and 2,4,5-T as pre-emergence treatments for Johnsongrass seedlings. Diuron

and simazine were not effective in controlling Johnsongrass seedlings; however, their effectiveness was increased in mixtures with 2,4-D and they were more effective against winter-growing broadleaved weeds than the recommended TCA plus 2,4-D treatment. Detrimental effects on sugarcane yields were obtained from high rates of fall and spring applications of fenac on a clay soil but not on a silt loam. Three sugarcane varieties showed differential tolerance to a postemergence applications of diuron, dalapon, and bromacil.

B. Nematode Control

Sugar. While it has been known for several years that tomatoes may be lightly infected by the sugarbeet nematode (Heterodera schachtii), it has only recently been demonstrated in tests at Salinas, California, that the ability of the nematodes to attack tomatoes is increased by growing several generations of nematodes on tomatoes. Studies of hatching of sugarbeet nematode larvae from cysts have shown that hatching activity of sugarbeet diffusate can be decreased by heating at 15 pounds pressure or by the addition of 1,000 part per million or more of copper sulphate. Navy beans, pole beans, peas, clover, and alfalfa are all known to have a "trap crop" action on the sugarbeet nematode. Field trials at Salinas, California, designed to measure the practical effect of this action, indicated that the decrease of sugarbeet nematodes in soil where they were grown were not of sufficient magnitude to warrant choosing one of these in preference to any other rotation crop not susceptible to the nematode.

In experiments at Logan, Utah, the new nematocides O,O-diethyl O-2-pyrazinyl phosphorothioate (Zinophos) and tetrachlorothiophene (Penphene) were all less effective in controlling sugarbeet nematodes (Heterodera schachtii) than D-D Mixture at 25 gallons per acre. In a continuing project of correlating laboratory and greenhouse tests of resistance of sugarbeets to sugarbeet nematodes (Heterodera schachtii) with field performance, it is indicated that the two can be correlated only when the greenhouse tests are closely controlled.

Attempts to control nematodes of sugar canes at Baton Rouge, Louisiana, by the use of the fungus, Catenaria vermicola, have given inconclusive results though yields were increased where molasses was added as a food for the fungus.

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SUGARCANE AND SUGARBEET INSECTS
Entomology Research Division, ARS

Problem. Control of insects on sugarcane and sugarbeets is essential because of destructive plant diseases spread by insects and damage caused by insects feeding on the roots and foliage. Adequate control often requires use of insecticides with special care to avoid contamination of the harvested product with undesirable residues. Safe effective methods of control are especially needed for the sugarcane borer, the sugarbeet root maggot, and the beet webworm. Sugarcane mosaic has become more important in recent years and information on insect vectors of this disease is needed. Beet yellows and associated western yellows virus diseases of sugarbeets continue to threaten the sugarbeet industry. Emergency chemical control measures for the aphid vectors of the viruses of these diseases are urgently needed. Development of suitable control measures is handicapped by lack of adequate knowledge of the identity and ecology of the insect vectors and plant reservoirs of the two viruses. For long-range solutions to these problems, further investigations should be undertaken to find effective parasites and predators of sugar-crop pests and to develop varieties of sugarcane and sugarbeet that are resistant to insect attack. The usefulness of destruction of alternate host plants, and new approaches to insect control, such as the male sterility technique and attractants, should also be investigated. Research should aim to develop control methods without objectionable features. Key insect pests that require heavy use of insecticides for their control and thereby make the natural control of other pests on the same crops difficult are special problems that should receive emphasis in the search for nonchemical methods of control.

USDA AND COOPERATIVE PROGRAMS

The Department has a continuing long-range program involving basic and applied research on the insect problems of sugarcane and sugarbeet directed toward developing efficient and economical control methods. This program is cooperative with State and Federal entomologists, agronomists, and chemists in the States where research is underway, and with industry. Studies on sugarcane insects are conducted at Houma, La., Canal Point, Fla., and Mayaguez, Puerto Rico, and on sugarbeet insects at Mesa, Ariz., Twin Falls, Idaho, Logan, Utah, and Yakima, Wash.

The Federal scientific effort devoted to research in this area totals 9.0 professional man-years. Of this number, 1.0 man-year is devoted to basic biology, physiology and nutrition; 2.1 to insecticidal control; 0.8 to insecticide residue determinations; 1.1 to biological control; 1.0 to insect sterility, attractants and other new approaches to control; 0.1 to evaluation of equipment for insect detection and control; 0.6 to varietal evaluation for insect resistance; 1.7 to insect vectors of diseases; and 0.6 to program leadership.

In addition, natural enemies of the sugarcane borer in India are being studied under a P. L. 480 research grant Project A7-ENT-1 by the Commonwealth Institute of Biological Control, Bangalore, India. Parasites and predators found effective for borer control will be made available for use in the United States.

PROGRAM OF STATE EXPERIMENT STATIONS

Research in the States on insects affecting sugar production is concerned with disease transmission, biological studies and control.

On sugarbeets, studies are in progress on both curly top and yellows disease. Fields and desert breeding grounds are sampled to determine the population levels of insect vectors. The influence of date of planting, plant resistance, and other control practices such as foliar and seed applications of systemic insecticides are being evaluated for their effectiveness in reducing disease incidence.

The ecology of other insect pests of sugarbeets is also under investigation. Variations in temperature and other natural phenomena are being correlated with seasonal development. Records are obtained of overwintering sites, time of appearance in the spring, oviposition, pupation, emergence of late generations, host preferences, and the effects of various hosts on development.

Similar biological studies are being conducted on insect pests of sugarcane. In addition, insecticides and other agents are being evaluated for their effectiveness in control. The identity and importance of natural enemies and the effects of insecticides on beneficial species is being determined. Variations in responses of plants to insect attack are also under investigation. Survey methods are being developed to obtain a more accurate estimate of losses caused by insect attack.

Scientists are investigating the possibilities of control of the sugarcane borer by radiation. Mass rearing methods are being developed and various life stages of the insect subjected to gamma radiation to determine the levels necessary for sterilization. Light of different wave lengths and chemicals are being investigated to determine their usefulness as attractants to the sterilization source.

In all, 4.3 man-years are dedicated to research on insects affecting sugar production in the States.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Basic Biology, Physiology, and Nutrition

1. Sugarcane Insects. The annual 1963 harvesttime survey to determine sugarcane borer infestation and crop loss in Louisiana showed 12% of the joints of sugarcane bored, with an estimated crop loss of 9%. The

first-generation infestation in 1964 showed an estimated average of 549 borer-killed plants per acre. This average is slightly over 100% higher than the 1963 average and 14 times higher than the 1962 average. In Florida the sugarcane borer is a much greater problem in the newly expanded areas of sugarcane production than in old fields around Lake Okeechobee. In Puerto Rico the sugarcane borer continues to be the major pest of sugarcane with 6 to 9% of the joints bored, depending on locality. The yellow sugarcane aphid, Sipha flava, is increasing in Puerto Rico, encouraged by a major drought which occurred over parts of the sugarcane areas during most of the first half of 1964.

Laboratory studies conducted in Puerto Rico indicate that light intensities of less than 0.04 foot candles are necessary to initiate mating of the sugarcane borer. Under caged conditions sex ratios of 2:1 (male-female) resulted in the highest mating success with maximum viable egg production. Mating is usually accomplished within one hour, and one male is capable of successfully inseminating at least 4 females. Fully successful matings result in nearly 100% hatch when environmental conditions are satisfactory.

A new method of preparing sugarcane borer diets has resulted in a substantial improvement over diets previously considered satisfactory. Killing of sugarcane tissues with ether fumes apparently prevents masking of gustatory stimuli attractive to the sugarcane borer and borers feed immediately and energetically upon sugarcane treated in this way. Other diets tested were rejected in favor of the new diet. Control of contamination is essential in the mass rearing of the sugarcane borer. Mercuric chloride-soaked cotton plugs for vials containing single larvae, control externally introduced fungi and bacteria completely. Buffer systems in dietary media helped but have failed to suppress consistently and completely bacteria associated with the food itself.

2. Sugarbeet Insects. Studies of the beet webworm in southern Idaho showed that such weeds as redscale, Russian thistle, and lambsquarters are preferred food plants. The first 1 or 2 broods of the webworm develop on these weeds. Sugarbeets are subject to damage by the second and third broods, depending upon the season. Damage to sugarbeets is not correlated with numbers of moths in flight.

The leaf-mining larvae of the ephydrid fly, Psilopa leucostoma were first found infesting leaves of sugarbeet in the United States at Walla Walla, Wash., in 1962. The insect spread to the Yakima Valley in 1963 and was found throughout the Columbia Basin of eastern Washington in the spring of 1964. It appears later in the season and attacks leaves in greater numbers--20 to 40 or more small mines per leaf--than the spinach leafminer (Pegomya hyoscyami). The insect was controlled with repeated applications of demeton or phosphamidon sprays.

In Washington biweekly counts of the winged-migrant forms of the green peach aphid caught in two yellowwater-trap pans per sugarbeet field correctly forecast the time of aphid colonization and aphid population changes on the crop.

The sagebrush defoliator (Aroga websteri) described in 1932 from moths collected in eastern Washington some years earlier, was reported to have defoliated and severely damaged between 10,000,000 and 12,000,000 acres of sagebrush in the West in 1963. Removal of sagebrush would allow the growth of annual weeds suitable for breeding large numbers of the beet leafhopper.

B. Insecticidal and Cultural Control

1. Sugarcane Insects. In tests conducted in Louisiana in 1963, Guthion, carbaryl, and endosulfan controlled the sugarcane borer. Endrin and ryania are the currently recommended insecticides for the borer. Insecticide applications are recommended only after joints have begun to form, and whenever 5% or more of the stalks are infested with young larvae feeding in or under the leaf sheaths and which have not yet bored into the stalks.

In 1963 field tests in August, planted cane in Louisiana, endosulfan, carbaryl, Cl-47031, Cl-47470, 10B Thuricide, Cryolite BTB, Guthion, endrin, diazinon, Methyl-Ethyl Guthion, Bayer 25141, and Bayer 38156, were tested for control of the sugarcane borer. Bayer 38156 and 25141 were applied as foliar sprays, while all the other materials were applied in the granular form. Cl-47031 and Cl-47470 were each applied one time, while all the other materials, with the exception of Bayer 25141, were applied 3 times at biweekly intervals. Bayer 25141 exhibited pronounced phytotoxicity and the use of this material was discontinued after one application. All the insecticides tested gave significant reductions in numbers of deadhearts. Control ranged from 99% for endrin and diazinon to 65% for Cryolite BTB. Cl-47470, a systemic insecticide, showed promise, giving 88% control with one application. Endosulfan, carbaryl, Guthion, Methyl-Ethyl Guthion, and Bayer 38156, were highly effective. Cl-47031, 10B Thuricide, and Cryolite BTB gave 65 to 70% control.

In a small-plot replicated test in Louisiana comparing 19 insecticides for control of small soil arthropods associated with root rot diseases of sugarcane, chlordane at 2 pounds per acre was the most effective. Chlordane-treated plots produced 85% more cane and 98% more sugar than the check. Plots treated with other insecticides had significant increases in sugar, as follows: Telodrin - 75%, phorate - 67%, Kepone - 65%, V-C 13 - 64%, Bayer 25141 - 64%, and Bayer 37344 - 62%. Plots treated with Ciodrin, fenthion, and T. D. 183 gave less sugar than the 1,768 pounds per acre for the control.

2. Sugarbeet Insects. At Worland, Wyo., and Grand Junction, Colo., 1 or 2 ounces of phorate per acre in pelleted sugarbeet seed decreased beet leafhopper populations and reduced curly top by 49%. Yield was increased approximately 1 ton per acre and percent sucrose was increased, resulting in a net gain of 425 pounds of sugar per acre. At 2 ounces per acre in pelleted seed, phorate also reduced flea beetle damage to the cotyledons

and first 2 pairs of leaves 86% and leafminer damage 87%. At Logan, Utah, symphylans were controlled and stands of sugarbeets improved 25% by the use of pelleted seed containing either 1.5 ounces of Di-Syston or 3 ounces of V-C 13 per acre.

Seven new materials tested in the laboratory at Twin Falls, Idaho, as slurry treatments on sugarbeet seed showed promise as a control for the beet leafhopper and for prevention of curly top. However, in field tests all but Union Carbide 21119 were phytotoxic. Parathion and diazinon were recommended for the first time in 1964 for the control of wireworms, based on field tests in 1963. They are applied as granules broadcast and worked into the soil before planting. Two applications of phorate in a spray at a dosage of 1 pound per acre per application to small sugarbeet plants gave control of the green peach aphid superior to that of 2 applications of granular phorate. At harvesttime 18% of the beet plants that received 2 spray applications showed beet western yellows symptoms as compared to 52% in the nontreated check plots.

Laboratory tests against the beet webworm in Idaho revealed many promising new insecticides. Of 52 materials tested, 25 gave better than 95% control when larvae were caged on potted beet plants 1 day after spraying, which was as good as the DDT used as a standard. Twenty-three of the materials gave as good control as DDT one week after treatment and 15 gave very good control with as little as 0.25 pound per acre. Early applications of emulsion sprays of dimethoate at 1.5 pounds per acre to sugarbeets grown for seed in Utah reduced *Lygus* populations 58% and increased seed viability to 94% compared to 89% in untreated plots and 91% where toxaphene was used later in the season.

C. Insecticide Residue Determinations

1. At Yakima, Wash., numerous chemical analyses were made of samples of sugarbeets from experimental plots in Washington and Idaho for insecticide residues. These studies showed that persistent insecticides such as DDT, aldrin, dieldrin, and endrin cannot be used on sugarbeet foliage, soil, or seed without danger of contamination of the raw roots and dehydrated pulp with undesirable residues. On the basis of these studies it has been necessary to discontinue all recommendations for the use of DDT, aldrin, dieldrin, and endrin for the control of sugarbeet insects. The most outstanding findings were that 1/2 pound of dieldrin on 100 pounds of seed is sufficient to cause significant dieldrin residues in the raw sugarbeet roots grown from the treated seed. Also, the use of 5 pounds of aldrin per acre in the soil to control wireworms on potato one year was sufficient to cause excess residues in sugarbeets grown in the soil the following year. The work also showed that residues of these insecticides in the raw sugarbeets is not lost in processing the roots but is concentrated in the dehydrated pulp which is used in cattle feed.

A dimethoate emulsion concentrate spray (0.44 lb. dimethoate per acre in 9 gallons of water), applied with fixed-wing aircraft to sugarbeets in Washington infested with the green peach aphid, drifted to alfalfa due to an 8-10 m.p.h. cross wind. Residues were recovered on alfalfa at least 340 feet from the end of the spray plot 1 day after treatment and 1.4 ppm dimethoate was recovered from hay 110 feet from the plot 5 days after treatment.

D. Biological Control

1. Sugarcane Insects. The Cuban fly parasite of the sugarcane borer survived the two coldest successive winters of the century in Louisiana. In 1962 no parasites were recovered. In 1963 parasitization was 18%, the highest recorded since the conclusion of the introduction program in 1959. In June 1964, the parasite was recovered on several plantations in southeast Louisiana where it has become established. In one field on a plantation where the last releases were made in 1956, parasitization of first-generation borers was 8%. In Puerto Rico parasitization was above 55% during much of the year. Collections of borer eggs during the fall of 1963 in fields of summer-planted sugarcane in Louisiana showed an average parasitism of 43% by the native egg parasite Trichogramma. The 1961 and 1962 fall parasitism averaged 39 and 32% respectively. Parasitism usually averages about 75%.

Three parasites imported from India in connection with P.L. 480 project A7-ENT-1 are being tested on the sugarcane borer in Florida. One is an ichneumonid, Centeterus alternecoloratus, that parasitizes the prepupal and pupal stages of borers in India. The other two, a braconid, Rhaconotus signipennis, and a tachinid, Sturmiopsis sp., parasitize fourth and fifth instar borers.

E. Insect Sterility, Attractants, and Other New Approaches to Control

1. Sugarcane Insects. Chemosterilants tested in the laboratory in Puerto Rico caused heavy mortality of the sugarcane borer. Sterilization by means of heat was unsatisfactory because mean lethal and mean sterilization temperatures are unduly close to one another.

Work on sex attraction of the sugarcane borer has been initiated in Puerto Rico. Attractant extracts were made using methylene chloride at 5cc, 2cc, and 1cc per female abdomen. Extracts were placed on filter paper in a venturi-equipped wind device built for attractant studies. Courtship behavior did not start until light levels were reduced below 0.04 foot candles. Previous study with female borer moths resulted in similar conclusions.

F. Varietal Evaluation for Insect Resistance

1. Sugarcane Insects. In Louisiana, 26 new parent varieties of sugarcane with some degree of resistance or tolerance to the sugarcane borer were recommended to sugarcane breeders for use in developing new commercial varieties. Of 358 sugarcane varieties tested in hand infested plots for borer resistance, 27% had fewer joints bored, and 31% produced more sugar than commercial variety C. P. 36-105 used as a standard. Twenty-two agronomically promising unreleased varieties were grown in a replicated test in Louisiana under each of two controlled levels of borer infestation. Five showed a marked degree of tolerance. The 5 varieties, C. P.'s 58-15, 58-48, 58-51, 59-56, and 59-29 were among those showing the greatest tolerance the previous year. Other varieties showing the least loss in sugar per acre were C. P. 57-98, C. P. 58-2, L. 56-25, C. P. 58-43, C. P. 59-53, and L. 56-11. The first 3 of these were among the most tolerant in 1962. In terms of loss of pounds of sugar per ton of cane, varieties C. P. 59-62, C. P. 59-29, C. P. 58-48, C. P. 59-53, and C. P. 58-15, showed the least loss in 1963. All but the last of these varieties also showed a relatively small loss in 1962. Of 369 varieties assigned C. P. and L. numbers in 1963 that were examined for borer infestation and injury, only 9 appeared to be resistant to the borer. Thirty-four appeared to be very susceptible and the rest moderate to average in susceptibility.

G. Insect Vectors of Diseases

1. Sugarcane Insects. Spring populations of sugarcane mosaic vectors, the corn leaf aphid (Rhopalosiphon maidis), the rusty plum aphid (Hysteroneura setariae), and the sowthistle aphids (Amphorophora sonchi and Dactynotus ambrosiae), were higher in 1963 than in the 2 previous years. These species were the most generally distributed of the 7 known vectors of sugarcane mosaic. Studies were continued to determine the feasibility of sugarcane mosaic control by means of chemical control of the vectors. In a 22-acre block of 2 susceptible varieties of sugarcane, 4 biweekly applications of demeton in the fall and 5 in the spring reduced mosaic spread by 30% in one variety that had been planted the previous summer, while in the other, a fall-planted variety in which the chemical was similarly applied in the spring but with only 2 fall applications, disease infection was reduced by 64%.

Transmission studies showed that the brick-red sowthistle aphid, which appears to be the most efficient vector of the sugarcane mosaic virus, can become viruliferous after feeding for 5 minutes and transmit the virus within a 5-minute period. The insect can transmit the virus to more than one plant although it remains viruliferous for only a short time. These studies indicate that the sugarcane mosaic virus is nonpersistent in that a latent period in the vector before being transmitted is not necessary. Viruliferous brick-red sowthistle aphids were able to transmit the virus to healthy sugarcane plants treated 24 hours previously with demeton before being killed by exposure on the treated plants.

2. Sugarbeet Insects. At Mesa, Ariz., field-plot experiments showed that high fertility reduced damage to the beet seed crop caused by infestations of green peach aphids carrying viruses of either beet yellows or beet western yellows, or both. Plots infested with aphids carrying both yellows viruses yielded 3636 pounds of seed per acre with average fertility and 4394 pounds with additional fertilizer, a significant increase of 21%. Plots not infested with yellows-infective aphids produced 4282 pounds of seed under average fertility conditions and 4740 pounds with additional fertilizer. The viability of the seed was unaffected by the yellows viruses. Previous work showed the value of aphid control under yellows conditions. These data indicate the value of maintaining high fertility if the sugarbeet seed crop is likely to be subjected to infestations of yellows-infective green peach aphids.

Small and cull sugarbeets left in the field at harvest or in tare piles at beet-receiving stations provided an overwintering source of aphid-borne beet and beet western yellows viruses in eastern Washington. Because the mild winter of 1963-4 these overwintering virus sources and the green peach aphid were unusually abundant. The most severe beet western yellows infection was not found in fields where the greatest populations of the green peach aphid had developed but in fields with irregular terrain on the leeward side of rolling hills, or in ravines, where viruliferous green peach aphids settled out of the prevailing west winds.

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CROP HARVESTING AND HANDLING OPERATIONS AND EQUIPMENT
Agricultural Engineering Research Division, ARS

Problem. This area is concerned with the development of equipment and methods for efficiently harvesting and farm handling of sugar crops. The cost of harvesting and farm handling of these crops is costly and reduces returns to the producer. In addition, supply and adequacy of manpower for these operations are becoming progressively less satisfactory.

USDA PROGRAM

Studies concerned with improving equipment and methods for harvesting sugarcane are being conducted at Houma, Louisiana, in cooperation with the American Sugar Cane League. Total professional man-years is 1.0.

Work in this area is also underway at the University of Sao Paulo, Brazil. Studies are concerned with the mechanization of sugarcane production. This project, financed with PL 480 funds, is being carried under a contract with the University of Sao Paulo.

REPORT OF PROGRESS FOR USDA AND COOPERATIVE PROGRAMS

SUGARCANE HARVESTING EQUIPMENT

Cutter-Cleaner-Loader-Type Sugar Cane Harvester. Major design and construction changes on the USDA experimental sugarcane harvester consisted of providing a wider range of telescoping header arms and toppler clearance. This resulted in more effective and efficient harvesting under a wide range of field conditions and permitted the machine to operate either direction on the rows regardless of direction the cane might be down. These investigations are in cooperation with the American Sugar Cane League who provided some financial assistance and program direction in an advisory capacity.

Gathering Assembly for Down Cane. A telescoping gathering assembly was redesigned with the stroke increased from 19 to 32 inches to provide a wider range and flexibility in gathering down cane. The toppler height range and clearance for disposal of tops was increased to assist in preventing chokes under more adverse conditions. These modifications provided more effective operation of the harvester.

Effect of Stripper Combination in Harvester Efficiency. Harvester efficiency studies were made on the USDA machine comparing stripper combinations, no strippers, both strippers, only lower strippers and only upper strippers on three varieties of sugarcane. The use of both strippers as compared to no strippers reduced harvester efficiency 3.33 percent (significant at .05 percent level) when harvesting variety CP48/103, second stubble. The harvester

efficiency for this variety was reduced 2.28 and 2.21 percent (significant at .05 percent level) for lower and upper strippers, respectively, compared with no strippers. No significant differences in harvesting efficiency could be measured between use of stripper combinations on varieties CP52/68 and CP44/101, both second stubble. The quantity of trash in the harvested cane was reduced 1.98 percent (significant at .01 percent level) when both strippers were used compared to no stripping for variety CP44/101, second stubble. The quantity of trash for this variety was reduced 1.30 percent (significant at .05 percent level) by use of both strippers compared to only upper strippers. The lower strippers reduced the quantity of trash 1.40 percent (significant at .05 percent level) compared to use of no strippers. No significant differences in trash content of harvested cane could be measured between stripper combinations on varieties CP48/103 and CP52/68. No significant difference could be measured as to the effect of yield upon harvester efficiency for the various stripper combinations in yields ranging from 25.5 to 37.8 standard tons per acre.

Harvester Efficiencies of 94 to 98 percent have been obtained cutting erect cane. For badly lodged cane, efficiencies of 80 to 90 percent have been obtained.

Distribution of Trash, Cane and Sucrose measured in 1-foot increments above the ground surface varied widely between erect and lodged canes. Lodging of variety 58/48 appears to have a depressing effect upon indicated recoverable sucrose. Seventy-seven and eight-tenths percent of the variety CP58/48 was in a zone of 0 to 2.19 feet above the top of the row. The 0 to 2.19 foot zone contained 47.4 percent of the total trash. Separation of the trash from millable cane is the main problem in harvesting badly lodged or recumbent cane. The removal of leaves and tops from a ton of whole cane produced 26.61 pounds more sucrose in the milling process than when the cane was not cleaned.

A 5-Year Contract for Investigations in Mechanization of Sugarcane Production was executed in the spring of 1962, under PL 480 funds with the University of Sao Paulo, Brazil. Research is currently underway on two sub-projects.

Minimum Tillage in Sugarcane. In Brazil, most of the sugarcane is planted after the soil has been plowed approximately 6 inches deep, harrowed, and then furrowed to a depth of about 10 inches in which bottom the cane stalks will lay after fertilization. Two plowings and two harrowings are a common practice but result in high power requirement. Also, the cane stalks lay on a compacted region in the furrow bottom and the initial phases of growing take place under a compacted soil. For the purpose of reducing the total power requirement for seed bed preparation and to study the effect of other practices on yield, tests were conducted in 1963 comparing the conventional method with planting in furrowed plots that had not been previously plowed or harrowed. While production data is not yet available, the following

observations have been made: (a) There appears to be no difference in germination between treatments; (b) greater tillering was evident in the plowed plots; (c) at the critical rainfall period, there was no difference in soil moisture between the plowed and unplowed plots; and (d) there was no difference in weed population.

Development of a Sugarcane Harvester. Sugarcane burning prior to hand harvest is a general practice in the State of Sao Paulo. Based on information from farmers, it was felt that mechanization of the harvesting operation could be made by two machines, one of which should cut the tops and strip stand cane. This stripping unit should work ahead of a mounted cane harvester which would cut the cane at the base and load it on a wagon. These two units working simultaneously in the field would eliminate the burning practice and also simplify the design on the harvester itself. Progress to date includes the mounting of a prototype stripping unit on a tractor to further observe the possibility of stripping stand cane. Wire ropes three-eighths-inch in diameter fastened to a rotor comprise the stripping unit. At a speed of 650 r.p.m., no leaves or trash accumulated around the rotor. Optimum tractor speed was 1.8 m.p.h. The unit was operated on one side of a row of hand-topped stand cane. After several tests, a reasonable stripping job was obtained. However, several problems with the unit include: The wire ropes cause some stalk bruising and their life is short due to the constant flexing.

PUBLICATIONS - USDA AND COOPERATIVE PROGRAMS

None.

II. NUTRITION, CONSUMER AND INDUSTRIAL USE RESEARCH
SUGARCANE - PROCESSING AND PRODUCTS
Northern Utilization Research and Development Division, ARS

Problem. Quotas established by the Sugar Act effectively prevent the accumulation of surpluses by limiting production to estimated requirements at stable, low prices for sugar. Prices received by farmers of the United States and Puerto Rico for sugarcane are based upon the recoverable sugar content of the cane; and the rising costs of production and processing make imperative the more efficient recovery of increased amounts of sugar to provide adequate returns for both processors and growers. Currently recovery of 75 percent of the total sugar in the cane is considered satisfactory in Louisiana, and about 83 percent in Puerto Rico and Hawaii. Improved processing methods could increase the recoverable sugar to at least 85 percent in Louisiana and over 90 percent in other areas. The development of more efficient processing methods depends in turn upon the acquisition of adequate data on the quantitative composition of juices extracted from sugarcane, and of materials processed to recover sugar. The chemical industry provides a promising potential for the utilization of additional sugar since more than 15 billion pounds of chemical products are produced annually and sold to every section of American industry. More information is needed on the chemistry and properties of products from sugar to expand their utilization and on the application of these derivatives in the production of plastics, protective coatings, emulsifiers, detergents, and the like.

USDA AND COOPERATIVE PROGRAMS

The major part of the Department's research program on sugarcane processing and products is maintained at the Southern Utilization Research and Development Division, New Orleans, Louisiana. At the Northern Division, Peoria, Illinois, the Department maintains a long-term continuing program involving microbiologists and biochemists engaged in basic and applied research on the fermentative conversion of sugar to industrially useful organic acids.

The Federal program at Peoria, Illinois, totals 2.5 professional man-years, all of which is devoted to new and improved products, specifically, fermentative conversion of sugar to α -ketoglutaric and 2-ketogluconic acids.

In addition, the Department, through the Northern Division, sponsors research in this area under a grant of PL 480 funds to the Institute of Biological Chemistry, University of Rome, Rome, Italy, for studies on the preparation and characterization of dextran derivatives (5 years, 1961-1966). This research is under the subheading, new and improved products.

PROGRAM OF STATE EXPERIMENT STATIONS

Basic and exploratory studies are being carried out at the Puerto Rico station to determine by the use of ion-exchange procedures the possibility of producing sugars that may be utilized in the production of hard candies and similar products without further purification. Experiments will be carried out in pilot-plant scale to evaluate scaling-up the process and to determine operating costs.

Research is also in progress to develop pilot-plant fermentation procedures for use in fermenting as efficiently as possible molasses mashes to produce high quality rums. Other work centers around development of pilot-plant distillation procedures for use in distilling fermented mashes and development of analytical procedures for quality appraisal of rums. A continuous search for new strains of yeast suitable for the fermentation of blackstrap molasses and other materials derived from sugarcane is conducted.

In cooperation with the USDA, several storage and other experiments pertaining to the quality of sorgo juice for sirup and sugar production are conducted annually at the U. S. Sugar Plant Field Station, Meridian, Mississippi. Chemical studies center around total sugars, dextrose, levulose, sucrose and nitrogenous components.

Indiana research seeks to synthesize analogues of important metabolic sugars wherein hetero atoms such as sulfur, selenium or nitrogen replace the normal ring oxygen atom. Sugar analogues and their derivatives will be tested for usefulness as a medicine or as agricultural chemicals.

The research effort on utilization of sugarcane is 3.9 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. New and Improved Products

1. Production of α -ketoglutaric and 2-ketogluconic acids. Current studies have improved the reproducibility of production of α -ketoglutaric acid with Pseudomonas chlororaphis. Yields, based on glucose, in laboratory-scale equipment are consistently at about 50 percent by weight and occasionally reach 59 percent. Although yields in 20-liter fermentors have not yet reached 50 percent, there appears to be no reason why yields of α -ketoglutaric acid in large-scale equipment should not ultimately equal those obtained in the laboratory. Nevertheless, for the process to be economically attractive, inexpensive means for separating α -ketoglutaric and 2-ketogluconic acids, which are coproducts of the fermentation, will be required. Study of production of 2-ketogluconic acid with Serratia marcescens in 20-liter fermentors was continued. Yields were increased to 90-100 percent by weight in 16 to 24 hours on a medium containing 12 percent glucose. This process gives higher yields in less time than that now used industrially.

Several million pounds of 2-ketogluconic acid are used annually in production of isoascorbic acid, an antioxidant for various food products including meat. A number of industrial companies have requested cultures for making pilot runs or have inquired about the new process, which is the subject of a public service patent.

2. Studies on dextran derivatives. Work has been completed on metal-catalyzed depolymerization of dextran and on the stability of dextran solutions to heat; progress has continued on interaction between dextran derivatives and proteins, dyes, and metal ions. Preparation is being attempted of derivatives having one highly reactive functional group per dextran molecule. This research is being conducted by the Institute of Biological Chemistry, University of Rome, Rome, Italy, under a PL 480 grant.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

New and Improved Products

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*Research supported by PL 480 funds.

SUGARCANE - PROCESSING AND PRODUCTS
Southern Utilization Research and Development Division, ARS

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USDA AND COOPERATIVE PROGRAM

The Department has a continuing long-term program involving at the Southern Utilization Research and Development Division organic chemists, physical chemists, and chemical engineers engaged in basic research on the composition and properties of sugarcane, sugarcane juices and derived products, and in applied research directed to the development of new and improved sugarcane processing technology.

Basic and exploratory studies are carried out at New Orleans, Louisiana, on the composition of sugarcane and sugarcane juices as a basis for developing more efficient methods for economical production of high grade end products. Present emphasis is on the composition and properties of the "gums" and other complex, non-sugar polysaccharide constituents which reduce the recovery and impair the quality of raw sugar. Materials used in this research are being obtained from cane processed for pilot-plant experiments in cooperation with the American Sugar Cane League. In cooperation with the Cane Sugar Refining Research Project, Inc. -- an association of commercial sugar refiners that maintains three research Fellowships at the Southern Division -- research is also in progress to investigate the fundamental chemistry and physics of processes employed in the refining of raw sugar, and of novel methods of purification devised to improve the efficiency and economy of sugar refining.

Research on new and improved processing technology is being conducted at New Orleans, Louisiana, the U. S. Sugarcane Products Laboratory, Houma, La., and the Audubon Sugar Factory (Louisiana State University), Baton Rouge, Louisiana, to develop on a pilot-plant scale novel and more effective means of clarifying sugarcane juice, and improved methods of processing and purifying sirups to obtain greater recovery of raw sugar of higher quality at lower costs. This research is planned and conducted in close cooperation with the American Sugar Cane League and individual sugar companies. Sugarcane for the work is furnished by the League and use of the Audubon Factory for milling of the cane through the cooperation of Louisiana State University. Cooperation is also maintained with the Crops Research Division, ARS (U. S. Sugarcane Field Station, Houma, La.). Informal cooperation is maintained with the industry in evaluating quality of raw sugar and economic aspects of new processing methods.

Other research on chemical composition and properties has been initiated under a grant of P.L. 480 funds to Kyoto University, Kyoto, Japan, for isolation and identification of the nucleic acid derivatives of cane molasses, in order to obtain information applicable to expanding the utilization of molasses industrially and in feeds (project duration - 2 yrs.).

The Federal in-house scientific effort at the Southern Division devoted to research in this area totals 11.3 professional man-years. Of this total 4.4 are devoted to chemical composition and physical properties and 6.9 to new and improved processing technology. P.L. 480 research involves 1 grant for research on chemical composition and physical properties.

PROGRAM OF STATE EXPERIMENT STATIONS

Basic and exploratory studies are being carried out at the Puerto Rico station to determine by the use of ion-exchange procedures the possibility of producing sugars that may be utilized in the production of hard candies and similar products without further purification. Experiments will be carried out in pilot-plant scale to evaluate scaling-up the process and to determine operating costs.

Research is also in progress to develop pilot-plant fermentation procedures for use in fermenting as efficiently as possible molasses mashes to produce high quality rums. Other work centers around development of pilot-plant distillation procedures for use in distilling fermented mashes and development of analytical procedures for quality appraisal of rums. A continuous search for new strains of yeast suitable for the fermentation of blackstrap molasses and other materials derived from sugarcane is conducted.

In cooperation with the USDA, several storage and other experiments pertaining to the quality of sorgho juice for sirup and sugar production are conducted annually at the U. S. Sugar Plant Field Station, Meridian, Mississippi. Chemical studies center around total sugars, dextrose, levulose, sucrose and nitrogenous components.

Indiana research seeks to synthesize analogues of important metabolic sugars wherein hetero atoms such as sulfur, selenium or nitrogen replace the normal ring oxygen atom. Sugar analogues and their derivatives will be tested for usefulness as a medicine or as agricultural chemicals.

The research effort on utilization of sugarcane is 3.9 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Basic Studies of the Chemical Composition and Physical Properties of Sugarcane Juice and Its Products. More complete characterization of the alcohol-precipitable, water-soluble gum constituents from reconstituted raw cane juice solids was obtained by determinations of the pentoses as well as the hexoses in hydrolysates. Glucose predominates in all of the preparations analyzed; together with percentages of fructose, galactose, arabinose, xylose, and rhamnose, 82.5% of the total composition of one preparation has been accounted for. Analyses of preparations from thirteen different samples of juice solids provide evidence that some of the juices obtained in pilot plant processing experiments contain dextran, which is not separated readily from the gum. A large, uniform supply of gum as free of dextran as possible has been obtained from two tons of cane specially handled and processed promptly in a small, clean mill. This material will be used in research continuing under a recently initiated project on fundamental investigation of the soluble, non-sugar polysaccharides of sugarcane. An individual polysaccharide has been isolated from the gum complex. It has a specific rotation of -43° , a molecular weight in excess of 100,000, and constituent sugars consisting of glucose, arabinose, xylose, fructose, and rhamnose.

Its isolation is a major step toward the elucidation of the nature of the high molecular weight, alcohol-precipitable substances of sugarcane juice, which reduce the recovery and impair the quality of raw sugar. Characterization of this levorotatory polysaccharide will make it possible to develop not only a method for determining its presence in juices and syrups but also a purification process to reduce its concentration before the sugar is crystallized. (S5 1-71).

Under a P.L. 480 grant at Kyoto University, Japan, research to isolate and identify the nucleic acid derivatives that occur in sugarcane molasses is in its initial stages. Progress is being made in applying techniques such as thin layer chromatography, ion exchange chromatography, and continuous liquid-liquid extraction to the isolation of nucleic acid derivatives. There is evidence that cytosine, cytidine, uracil (or uridine), adenosine and adenine are present in cane molasses; they are presently being isolated and further identified. Later, the research will be extended to a study of the occurrence of nucleic acids in cane juice. The basic information obtained in the project is expected to be useful in assessing the role of

minor non-sugar components in sugarcane processing and in the use of cane molasses for feed and industrial applications. (UR-A11-(50)-7).

2. Investigations of the Fundamental Chemistry and Physics of Sugar Refining. In cooperation with the Cane Sugar Refining Research Project, Incorporated, an association of commercial sugar refiners, research under a new project is being directed toward improving the recovery of sugar through basic studies of the chemistry and physics of refining operations. Reduction of losses by only one percent would result in a gain of approximately 15 million dollars per annum to the domestic sugar industry, and like savings may be realized from reduction in costs through automatic and more exact control of refining. This fundamental research on the basic chemistry and physics of the refining process for sugar will foster better understanding of the clarification process. Facets of the project include measurement of the molecular weight of sugarcane gums, a new method for the specific determination of glucose, and analysis of clarifier scums. (S5 1-77).

B. New and Improved Processing Technology

1. Processing Procedures to Improve the Refining Quality of Raw Sugar. Pilot-plant development of processes to improve the refining quality of raw sugar is continuing under a new project. The USDA pilot plant for juice clarification was used to capacity during the season to determine optimum dosage rates for two flocculants in clarification and to measure clarification efficiencies on commercial canes harvested mechanically and by hand. This work demonstrated flocculant NALCO D-1782 to be equal to Separan AP-30, which has been used commercially for several years, both performing well at 2 to 6 p.p.m. on machine- and hand- harvested crops and improving clarified juice quality for cane harvested during all kinds of weather. Tests on the newest commercial variety, C.P. 55-30, provide assurance of satisfactory processing in expanded cultivation. Relationships between filterability, content of insolubles, and refinery performance of selected raw materials were determined in a refinery through the first three processing steps of affination, clarification, and filtration. Refiners and raw sugar producers have evinced great interest in the simple and rapid Millipore filterability test, which determines the efficiency of removal of insolubles at each step, indicates the raw sugar best suited to a given refinery, and may provide an additional criterion of raw sugar quality. (S5 1-80, Pending).

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Chemical Composition and Physical Properties

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SUGAR BEETS - PROCESSING AND PRODUCTS
Western Utilization Research and Development Division, ARS

Problem. Sugar beets are mainly processed for sugar; a very small proportion is used for livestock feed. Sugar beets are declining in sugar content and rising in impurities. The traditional processing methods for sugar manufacture cannot cope efficiently with beets whose lower quality is due in part to excess nitrogen fertilizer, used to improve tonnage yields. Improved processing procedures should benefit both the growers and processors. It is known that small concentrations of certain chemicals in beets affect processing quality but not enough information is yet available to devise new economical procedures for high-impurity beets. Because costs of producing beets and processing sugar are rising whereas per capita consumption and price of sugar are essentially constant, all factors important to utilizing the crop must be examined to improve processing. There is still much to be learned about the composition of sugar beets, juices, pulp, and crude sugar. Sugar losses resulting from spoilage and respiration of beets held at processing plants cannot be prevented by existing methods. Only an expanded research program can provide the needed information at an early date.

USDA AND COOPERATIVE PROGRAM

Both basic research and process development studies on sugar beets are being conducted in the Western Utilization Research and Development Division's headquarters laboratory at Albany, California and under P.L. 480 grants in Calcutta, India and Jerusalem, Israel. The basic research program involves a comprehensive study of the naturally-occurring sugar beet and beet juice constituents, both carbohydrate and non-carbohydrate. Biochemical studies of the carbohydrate constituents aim to determine their origin leading to the development of methods for the reduction or elimination of those which decrease sucrose. Chemical studies of the non-carbohydrate constituents provide information to ameliorate effects of adverse constituents. Although Federal research on new products from sucrose (sucrochemicals) has been terminated, studies continue under P.L. 480 grants on the reactions of sucrose with vegetable and animal fats and oils, to produce new and useful compounds having special hydrophilic and lipophilic properties. Processing research on sugar beets deals with the effects of the many variables which influence the efficiency of recovery of sucrose. Pilot-scale sugar beet processing facilities are used to test these processing variables and to evaluate new and improved processing techniques.

The Federal program of research in this area totals 7.8 professional man-years. Of this total, 3.6 are assigned to chemical composition and physical properties; 4.2 to new and improved products and processing technology. In addition, the Division sponsors, under P.L. 480, one basic research project and one on product developments.

PROGRAM OF STATE EXPERIMENT STATIONS

The station program on sugar beet utilization is concerned with chemical composition of the beets. The effects of management, genetics, and environmental factors on yield and quality of sugar beets, including sucrose content of root and purity of juice are being determined. Other research, while serving projects designed to consider possibilities of growing beets in several new areas, also provides data on composition and the influence of environment and practices of fertilization and management on yield and quality of sugar beets.

The total research effort devoted to this work is about 5.2 professional man-years.

PROGRESS -- USDA AND COOPERATIVE PROGRAMS

A. Chemical Composition and Physical Properties

1. Sugar Beet Composition. Carbohydrate transformations during storage of sugar beets between harvest and processing are important to the sugar processor. Indirect losses of sugars and production of new compounds deleterious to the recovery of sugar have not been completely evaluated. It is known that these new compounds make it harder to extract sucrose. Investigations of the effect of processing methods on the accumulation of non-sucrose carbohydrates depend upon the development of better analytical methods. Thin-layer chromatography promises to be a good method to observe carbohydrates from beets and stored beet juices and the changes that occur in them. Galactinol has not been found in stored beet juices from California but kestose and raffinose accumulate after less than two months' cold storage of beets. When sugar beets were stored in the cold for nearly three months to attain high levels of raffinose and kestose and then returned to room temperature, kestose and raffinose appeared to diminish. Under the room temperature storage conditions reducing sugar rose to an unacceptable high value.

An analytical study of constituents of California sugar beets was concluded. Sucrose, reducing sugar, betaine, anions, sodium, potassium, chloride, marc, and soluble nitrogen were determined. Simple correlations of the non-sugar constituents against purity measurements of beet juice were highly significant and suggest the need for new methods of determining ionic impurities. The highly negative correlation of sodium and potassium with juice purity offers a possibility for routine measurement of these ions as an index of juice quality.

Preparation of trimethylsilyl ether derivatives of molasses carbohydrates allows a satisfactory qualitative and semi-quantitative analysis by use of gas-liquid chromatography. Attempts will be made to further develop this technique into a quantitative method for beet carbohydrates.

B. New and Improved Products and Processing Technology

1. Juice Diffusion. Further studies on lime treatment of sugar beet cossettes before diffusion showed that the juice produced is very much easier to clarify than juice from untreated cossettes. The overall lime use was reduced in laboratory tests from 2 or more to 1% of the weight of beets without sacrifice of clarity, filtration rate, sedimentation rate, or purity. Acetate ion increased, however, which means that sodium carbonate addition would be necessary in order to reduce lime salts. The pulp produced from this lime process was hard and tough and could be pressed to higher solids content with a hydraulic press than non-treated pulp. Factory-scale pressing tests with the treated pulp were drier, too, but clogged the presses some. Some of the older presses used in processing plants may be inadequate to take advantage of this improved procedure. Tests in commercial pressing equipment having a positive feed would be desirable and would demonstrate to the industry the savings in drying costs that could be made from pressing a tougher pulp.

2. Beet Juice Purification. Experiments using ion exchange and ion exclusion were conducted and appear promising as means for separating non-sugars from sucrose in beet sugar manufacturing. Small molecules such as amino acids diffuse into the ion exclusion resin and are partially eliminated whereas large molecules such as colored compounds and colloids from sugar beet juice pass through the resin and are eliminated. The resin therefore rejects non-sugar molecules in two ways which promise higher elimination efficiency than other purification schemes. In static resin columns this separation is accompanied by large dilution of the sugar. A practical means is being sought to develop a continuous countercurrent movement of juice and resin.

Sugar beet pulp from limed cossettes or pulp treated with lime under controlled conditions was converted to a thickening agent with possibilities for use in fire fighting compositions containing ammonium phosphate. Studies are continuing with tests conducted in cooperation with the United States Forest Service and the California State Division of Forestry. Variability of available pulp creates some uncertainty as to the best method for preparation of the thickening agent, and investigations will continue towards developing a general process for the pulp.

3. Sucrochemicals. The domestic Federal program of research on sucrochemicals was terminated in response to recommendations of the Sugar Research and Marketing Advisory Committee in 1963. A similar stand was taken by the Oilseed, Peanut and Sugar Crops Research Advisory Committee in 1964. Prior to termination of research on sucrochemicals, negotiations had taken place to provide P.L. 480 grants for work in this area at the Tropical Products Institute in London, England to develop surfactant compounds using sugar and animal and vegetable fats and at Jadavpur University in Calcutta, India to develop modified sugars that could be used for the synthesis of useful plastic substances. In the English work combinations of sucrose and low-cost

simple fatty acids were made but surfactant qualities were not high. Surfactant compounds using more complex hydroxy-substituted fatty acids such as ricinoleic acid from castor oil were prepared. High-quality surfactants prepared with these complex compounds had the high biodegradability of the simpler compounds. This project has been concluded.

The basic research in India has continued on the reaction of sucrose with sulfonochloride and similar compounds. Starting with tri-O-tosyl sucrose, new compounds with reactive end groups were synthesized including hydrazine and azido sucrose. Reactive end groups such as these form the basis for linking monomers together to make plastics.

PUBLICATIONS -- USDA AND COOPERATIVE PROGRAMS

Chemical Composition and Physical Properties

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NUTRITION AND CONSUMER USE RESEARCH

Consumer and Food Economics Research Division, ARS
Human Nutrition Research Division, ARS

Problem. The assortment and characteristics of foods available to consumers are constantly changing with the adoption of new production, processing, and marketing practices. Constantly changing also, as nutrition science advances, is our understanding of the nutritional needs of man and the manner in which these needs can best be met by food. To help meet the Department's responsibility to advise consumers on the quantity and variety of foods that will assure maximum benefit and satisfaction, research must continue on the nutritional requirements of persons of all age groups, and on the nutrient and other values of foods and on how to conserve or enhance these values in household preparation and processing. Periodic surveys of the kinds and amounts of foods consumed by different population groups and individuals also are essential for evaluation of the nutritional adequacy of diets and to give the guidance needed for effective programs in nutrition education. Information from such surveys provides assistance needed in market analyses for different commodities and in the development and evaluation of agricultural policies relating to food production, distribution, and consumer use.

USDA AND COOPERATIVE PROGRAM

The Department has a continuing program of research concerned with (1) nutritive and other consumer values of raw and processed foods as measured by chemical or physical means and by biologic response; (2) effects of household practices upon the nutritive values and inherent qualities of foods, and the development of principles and improved procedures for household food preparation, care, and preservation; (3) surveys of kinds, amounts, and costs of foods consumed by different population groups and the nutritional appraisal of diets and food supplies; and (4) development of guidance materials for nutrition programs.

The research is carried out by two divisions of the Agricultural Research Service -- the Human Nutrition and the Consumer and Food Economics Research Divisions. Most of the work is done at Beltsville and Hyattsville, Maryland; some is done under cooperative or contract arrangements with State Experiment Stations, universities, medical schools, and industry. The total Federal scientific effort devoted to research in these areas totals 63.3 man-years. It is estimated that approximately 0.9 man-years is concerned with studies related to sugar.

Human metabolic studies and the related exploratory and confirmatory studies with experimental animals and microorganisms concerned with defining human

requirements for nutrients and foods are not reported on a commodity basis, though some of the work is applicable to this report. This basic nutrition research represents a total Federal effort of 26.7 professional man-years and is described in detail in the report of the Human Nutrition Research Division. Certain aspects of this research related to dietary carbohydrates are considered briefly in this report.

PROGRAM OF STATE AGRICULTURAL EXPERIMENT STATIONS

Nutrient Value of Food

Food composition and nutritive value are most frequently related to indigenous agricultural products. Specific and locally grown raw products are being extensively evaluated for essential nutrients, especially in Hawaii and Puerto Rico. Much work is related to changes induced by growing practices, processing and storage.

This program includes 36 projects in 23 States and is comprised of 23.4 professional man-years.

Properties Related to Quality and Consumer Use of Food

In the area of food preparation, products are related to quality by some measure. Special measures characterize certain classes of products; i.e., vitamin assays, enzymatic activity, water binding capacity, and changes in structural tissues. Combinations of these are involved in the quality evaluation work reported.

The structure of baked products as related to the physical and chemical properties of the starches used and supplementary products involved, as sugars is the subject of on-going basic research in the carbohydrate area. The physical structure of batters and doughs which are frozen is also under study.

This portion of the program includes 52 projects in 21 States and is comprised of approximately 50.1 professional man-years. This is a partial report of the State Experiment Station programs in food science and includes work undertaken by home economics departments. For research on food and fiber utilization see reports of the Utilization Research and Development Divisions.

Food Consumption and Diet Appraisal

The State program in food consumption and dietary appraisal extends the work of the Department to other segments of the population or to geographic areas not separately identified in the nationwide studies. Currently 12 States are contributing to this program. One regional project is designed to yield information regarding food purchase and consumption patterns of families with

preschool children. This research will provide information useful to both consumer and market interests.

The State program in this area totals 22.2 professional man-years.

PROGRESS--USDA AND COOPERATIVE PROGRAMS

A. Nutrient Value of Food

1. Tables of food composition. Research for the newly revised Agriculture Handbook No. 8, "Composition of Foods...raw, processed, prepared," has been supplemented by further research during the year and adapted to the needs of special projects.

Selected data from revised Handbook No. 8 have been made available in decks of punched cards and magnetic tape for research workers. Available in these forms are the data from Table 1, the nutritive values for 100 grams edible portion of the foods; from Table 2, nutritive values for one pound of food as purchased; from Table 3, selected fatty acids in foods.

Tables for the Department of Defense have been prepared on the composition of 630 food items procured by the Defense Supply Agency for feeding military personnel. Values for the composition of foods developed for Handbook No. 8 and many additional values provided by the Department of Defense were used to develop the data needed for the numerous special food products meeting military specifications.

2. Carbohydrates. Research is continuing on improving methods for analyses of individual sugars and applying them to various foods. Studies are concerned with extraction procedures, the determination of total and reducing sugars by conventional methods, and glucose and fructose by differential oxidation. Thin layer chromatography has been used for the separation and identification of some individual sugars from fruit and vegetable extracts.

Total and reducing sugars, sucrose, dextrin, and starch content of dry fat-free solids of composites representing 14-day diets for 16-19 year old boys were determined. The diets were based on USDA food plans at moderate cost. Variations among, and correlation coefficients between, different carbohydrate fractions were calculated. Sucrose content varied more than any other carbohydrate constituent. Variations among other carbohydrate constituents were not considered to be nutritionally important. A manuscript presenting these findings has been prepared for publication.

B. Nutrient Functions

Dietary carbohydrates. Dietary carbohydrates have often been considered chiefly as a source of energy, and little attention has been given to the possibility that the kind of dietary carbohydrate may be important in

nutrition. There is currently considerable interest in the possible role of different types of carbohydrates on lipid metabolism. Research recently completed in the Department has provided evidence that the kind of carbohydrate may influence metabolism under some conditions, apparently due not to the carbohydrate alone but to an interaction with other dietary ingredients. Two strains of rats (BHE and Wistar), previously shown to differ in their ability to metabolize fat, were fed diets identical in all respects except that the diets contained 39 percent sucrose, dextrose, or starch. The diet fed was one that had previously been found to result in shortened lifespan and acceleration of degeneration of the tissues of BHE rats when the dietary carbohydrate was sucrose.

By 150 days, the level of fat and cholesterol in the livers of BHE rats was high, with the greatest elevation when sucrose was fed. In Wistar rats dietary carbohydrate had little effect on liver fat or cholesterol. By 350 days, kidneys of BHE rats were enlarged and showed signs of structural changes; in Wistar rats this organ still appeared normal. The level of cholesterol in the serum of 150 day-old rats was low regardless of strain or kind of dietary carbohydrate. In the serum of 350 day-old BHE rats, however, the level of cholesterol was significantly elevated with the highest levels in the sera of rats fed sucrose. Serum cholesterol values were also elevated in 350 day-old Wistar rats but to a lesser extent than in BHE rats; no differences related to carbohydrate were seen.

BHE rats fed the sucrose diet had the shortest lifespan; no marked differences in survival were noted among the other groups. Nephrosis, a type of kidney damage, was the cause of death of most BHE rats, and the acceleration of this condition by diet seems to relate most closely to fat deposition in the liver. The cause of death of Wistar rats varied and appeared to be uninfluenced by diet. These findings have been presented at scientific meetings and will be prepared for publication.

C. Food Distribution Program

Revision of the publication "Quantity Recipes for Type A School Lunches" (PA 631), was completed in cooperation with the Agricultural Marketing Service and the Fish and Wildlife Service, U. S. Department of Interior. This recipe card file provides 324 quantity recipes or variations and other information needed in preparing Type A lunches in schools participating in the National School Lunch Program. Recommendations on preparing, storing, and handling a wide variety of foods were updated to take into account recent research findings and technology.

D. Food Consumption and Diet Appraisal

1. Planning for proposed nationwide survey, households and individuals.

A nationwide survey of household food consumption and of the food intake of individuals is scheduled for 1965. Plans have been developed for a survey

that would provide at least 6,000 household schedules and 10,000 individual schedules in the spring of the year with smaller household samples in each of the three succeeding seasons. The information on the week's food use to be obtained from each household is similar to that obtained in 1955, except that information on home baking practices will not be requested and information requested on home food production, home canning and home freezing will be reduced to allow interview time for questions on the food intake of individual members of households.

In preparation for the proposed first nationwide survey of the food intake of individuals, data obtained by recall on the 1-day intake of food from nearly 550 individuals of all ages in Washington, D. C., during June and July 1963, have been studied in relation to two controversial issues that concern collection of data. The survey findings indicate that for this group: (1) the nonresponse rate on food intakes from individuals is not influenced by taking a schedule on household food consumption first in comparison to taking none, nor is it influenced by taking a schedule on food intakes from half in comparison to all individuals in the family; and (2) homemakers report the amounts of food eaten by family members in terms of their individual servings far more often than as proportions of household amounts. Tabulations of the Washington data also are useful as a pretest for tabulation of the nationwide survey.

2. Effects of food distribution programs on diets of needy families. A survey of the food consumption of more than 800 households that were not participating in the food stamp program in St. Louis was made in May and June 1964 to determine the relation between usual family food expenditures and payments required for food coupons. Homemakers were asked also why their families did not participate in the program. Results of the analysis will guide the Department in revamping the St. Louis stamp program to make it more acceptable to eligible families and yet keep it within the limits of the program. Because of interest in the nutritional quality of food consumed by low-income families, an assessment may be made later of the dietary levels of these families. This is the sixth in a series of USDA food program surveys made in cooperation with the Marketing Research Division, ERS, to assist the AMS to administer the food stamp and direct distribution programs.

3. Nutritive value of national food supply. The nutritive content of the per capita food supply is calculated each year from estimates of quantities of foods consumed (retail weight basis) as developed by the Economic Research Service. This series, which begins with the year 1909, is being completely revised to incorporate newest estimates of per capita consumption, revised food composition data from Agriculture Handbook No. 8, and new information on the nutrients added to foods by enrichment and fortification.

A survey conducted by the Bureau of the Census for the Consumer and Food Economics Research Division has provided information for the years 1957-61, on quantities of enrichment ingredients supplied to processors to fortify

flour and cereal products. Through this program about one-third more thiamine, one-fifth more iron and niacin, and one-tenth more riboflavin are added to the Nation's diet than would be available if foods were not enriched.

For the first time, the enrichment survey was extended to include information on the quantities of ascorbic acid and vitamins A and D added to foods, thus furnishing a base line for future surveys. Currently the amount of ascorbic acid added to foods would be enough to increase the level in the per capita food supply by 5 percent. The contribution from synthetic vitamin A is 7 percent of which 6 percent is added through margarine. Vitamin D is not at present included in nutrient estimates.

4. Development of food budgets and other basic data for food and nutrition programs. Interpretation of nutrition research findings and their application to practical problems has continued as part of an ongoing program to assist nutritionists, teachers, health workers, and other leaders concerned with applied nutrition programs or nutrition policies. Information developed under this program is provided to many groups both within and outside the Department working on practical food programs, on questions relating to nutritional requirements, food consumption, nutritional importance of specified foods, and on nutrition education. Increased emphasis has been given this year to opportunities for disseminating information to the public through TV and radio, the press, conferences, workshops, and the Department's Food and Home Fair.

Nutrition Program News, a bimonthly periodical prepared for members of State nutrition committees and other community nutrition workers provides one channel for disseminating pertinent information about Federal programs and for reporting nutrition activities in the States. Issues this year included such diverse subjects as a report of the World Food Congress held in Washington, June 1963, "Labels on food products--the protection they give," and "Nutritional fitness for teenagers." Assistance to workers in nutrition programs has been provided also through consultation and program participation by staff nutritionists.

PUBLICATIONS--USDA AND COOPERATIVE RESEARCH

Nutrient Value of Food

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Nutrient Function

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Human Metabolism

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III. MARKETING AND ECONOMIC RESEARCH

ECONOMICS OF MARKETING

Marketing Economics Division, ERS

Problem. Descriptions and evaluations of markets and marketing functions are needed to determine the adjustments in marketing channels, locational patterns, institutional structures, practices, price-making processes, and other conditions which facilitate markets and systems of marketing to keep pace with other segments of our growing economy characterized by rapid technological, political and social change.

USDA AND COOPERATIVE PROGRAM

The Department conducts a continuing program involving a series of studies to show: (1) Detailed analyses of marketing costs and margins in the various stages and channels in handling, processing, transporting, and distributing sugar crops; and (2) Comparative efficiency and costs of present agencies, organizations, methods, and practices in performing the services involved at each important stage in taking the crop products from farms to final users.

The USDA scientific effort devoted to this research in fiscal year 1964 amounted to 2.8 professional man-years.

PROGRAM OF STATE EXPERIMENT STATIONS

Only one station has a project dealing with sugarcane. This study deals with the hauling of sugarcane by motor truck.

The scientific effort devoted to this research amounts to 1.1 professional man-years.

PROGRESS - USDA AND COOPERATIVE PROGRAMS

A. Structure, Practices and Competition

1. A study will be conducted to evaluate production and export potentials in various areas of the world in relation to the probable needs of the United States sugar market. The recent world shortage of sugar, together with the rapid use in world consumption since the end of World War II, have caused concern about the sources of supply of raw sugar for importation into the United States in future years. While the capacity to increase sugar production throughout the world appears very great, the problem is complicated by various systems of trade preference which channel exports into politically determined patterns.

2. Molasses in each of its major uses is subject to effective competition from alternate raw materials. In livestock feed, other materials such as milo, corn, bran and soybean flour may be substituted for molasses. In some chemical uses, petroleum gases such as ethylene and ethyl sulfate can be used in the production of various types of alcohols, while in citric acid production plans have been announced to use dextrose as a raw material in place of molasses. This substitution limits the price response of molasses to smaller supplies. However, no suitable substitutes for molasses have been determined to be acceptable in yeast production. Recent price increases in molasses have generated great production efficiency to offset these price changes.

B. Margins, Costs and Efficiency

1. While sugar prices prior to 1963 had not been rising as fast as factor costs incurred in the production and processing of sugar beets in the "Eastern" region (Michigan and Ohio), marketing advantages, as compared with producers in other areas are such that production in these States is likely to continue and probably increase somewhat. The total output of sugar in the region is much smaller than sugar consumption in nearby areas. As a result, transportation costs are minor and net returns per pound of sugar higher for producers in the "Eastern" region than for competing suppliers who must ship sugar longer distances.

2. Unusual movements of sugar prices in 1963 and 1964 together with an increase in beet sugar suppliers relative to total marketings have affected both the prices received by farmers for sugar beets and sugarcane and their share of the market price of sugar. Preliminary results of a study of these shifts and their relation to the structure of the United States sugar industry indicates that their effect varies significantly among major producing areas, and probably among growers within an area.

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Ballinger, Roy A. and Larkin, L. C., January 1964. Sweeteners used by food processing industries. AER-48. pp. 22.